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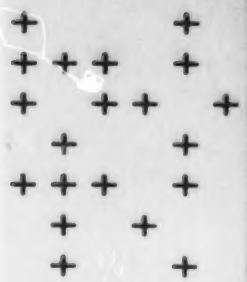
Les centres de recherche de Pêches et Océans:
Avantages économiques et technologiques"

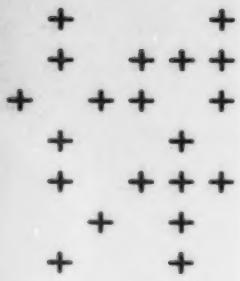
Scientific Excellence
Resource Protection & Conservation
Benefits for Canadians



Fisheries and Oceans
Research Centres

Economic and Technological Benefits

Economic and
Commercial Analysis
Directorate



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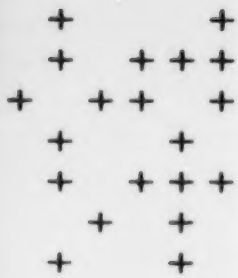


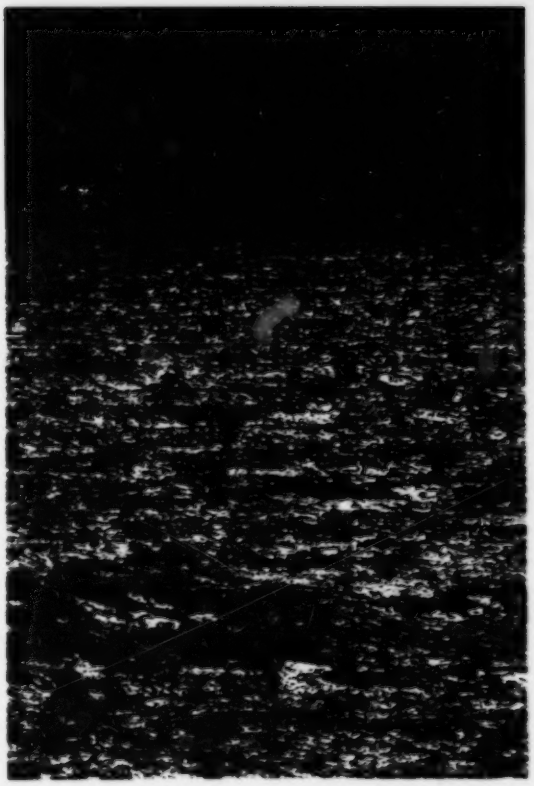
Preface

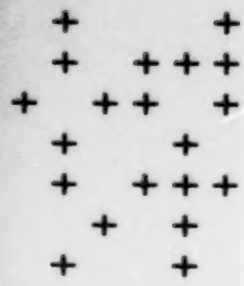
The ocean affects all Canadians, wherever they live in Canada. This country has the longest coastline in the world, the longest inland waterway, the largest archipelago, part of the world's largest freshwater system, some of the richest fishing grounds and some of the largest untapped offshore oil and natural gas reserves. Our economy is based on trade that travels by sea.

We need to know how to live with the oceans, use them safely, protect them from pollution, navigate their surfaces, and exploit their resources. We need to understand more about their influences on weather and climate.

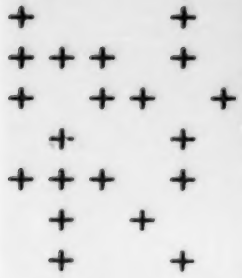
The federal government is responsible for much of the scientific effort on the oceans, and the largest ocean research effort is conducted by the Department of Fisheries and Oceans. The scientific activities of the department encompass fisheries as well as marine and freshwater environments. The Minister of Fisheries and Oceans recently announced a comprehensive Oceans Strategy which encompasses all of these activities.

Most studies of scientific activities assess the activities against scientific priorities. This study, however, focuses on the economic and technological contributions made by scientific activities in the Department of Fisheries and Oceans, documenting some of the many such benefits Canadians have received.





Executive Summary



This study documents some of the many economic, industrial and technological benefits Canadians have received as a result of the scientific activities of the Department of Fisheries and Oceans (DFO). The principal findings are expressed in quantitative terms and supplemented by qualitative analyses.

Because science and technology (S&T) is so important for economic growth and prosperity, debates are prevalent over how scientific work should be organized. Should the private sector do more, or participate at about the same level as at present? Should federal government departments provide more support for work done in other sectors? When should government undertake scientific activity?

DFO's interest in this debate is driven by the scientific challenge to advance its own mission. The department is, after all, a major player: 2100 science person-years (PYs) and $185 million in science expenditures illustrate the dimensions of its involvement in 1987-88. Six per cent of externally funded science and technology and eight per cent of all federally undertaken science and technology is attributable to Fisheries and Oceans.

A careful review of the department's S&T involvement has shown that DFO scientific activities maximize private sector development opportunities without sacrificing the mandate to conduct research in the public interest. DFO science expenditures produce thousands of spinoff jobs each year. A finding of this study is that each DFO PY is associated with five spinoff PYs in the private sector. And more than 80 per cent of DFO contracts are with private industry.

Another indicator of effectiveness is the degree to which DFO science expenditures benefit the regions most in need of economic, technological, and industrial development. Most Canadian S&T activity is concentrated in Central Canada but DFO's activity is focused on other regions. For example, 65 per cent of the jobs which spin off from DFO's science expenditures are produced in British Columbia and the Atlantic provinces.

With over $35 million in annual science contract expenditures, DFO is second only to Energy, Mines and Resources (EMR) in the value of science contracts and second-to-none in the number of contracts; more than 1000 are managed each year. Cooperation among departments and agencies is also apparent. This is illustrated by the fact that over 30 per cent of DFO science contract dollars are provided from programs administered by other departments.

Analysis of 600 DFO contracts over a three-year period shows a wide-ranging distribution to oceanic manufacturing and services firms. And, generally, DFO's approach has provided financial support without creating financial dependence.

Non-financial assistance has often been critical in encouraging successful technology transfer. Complexes of research institutions including non-profit organizations, universities, technical colleges, and science-based manufacturing industries cluster around DFO's research centres. They use the centre's facilities. They exchange ideas, human resources, and hardware.

DFO's scientific activities enhance regional economic development; provide support for basic and applied research; train qualified people; transfer technology and develop it in other sectors; enhance cooperation among governments and the private sector; and maximize privatization of DFO research while maintaining sufficient in-house capability to ensure that research which benefits the public will be undertaken.

Section I

Introduction

Issue

This study documents some of the economic, industrial and technological benefits resulting from DFO science activities.

Scientific and technological development is an important ingredient of economic development and well-being. Consequently, there is considerable debate in public and private circles over how best to foster science and technology (S&T). Government and industry fund and perform most Canadian S&T. However, their respective S&T roles changed dramatically in the seventies. In 1970, the federal government funded almost half of all S&T and industry supported about one-third. Since 1979, industry has led S&T funding, essentially having traded places with the federal government.

The national debate challenges science-based departments to demonstrate the considerable benefits from their scientific activities. DFO is one of only six federal departments that both fund and perform S&T: it finances six per cent of all federally funded S&T and performs eight per cent of all federal S&T. The department has a person-year (PY) allocation of about 2100 and spends about $185 million each year on science activities.

A 1986 DFO report entitled *Science at Sea* describes DFO science benefits to international organizations, other nations, other federal and provincial government departments, and other Canadian sectors. The present study is a more detailed analysis of some of those benefits. Because this is a more quantitative study and data are available for only some areas, its scope is more restricted.

The principal analyses focus on federal and private sector S&T expenditures, and federal scientific contracts. This report provides details of scientific contracts let by DFO's two largest research centres: the Bedford Institute of Oceanography and the Institute of Ocean Sciences.

The expenditure analyses do not fully document the economic, technological, and industrial benefits provided by all of DFO's scientific activities. They do show, however, some of DFO's most important impacts on S&T in other sectors and the relationship of these effects to the government S&T goals and means outlined in the recent statement by the Minister of State for Science and Technology. The goals are to enhance regional economic development, provide support for basic and applied research, train qualified people, and improve technology transfer to the private sector and universities. The proposed means are as follows: enhancing cooperation among governments and the private sector, transferring more technology from the public sector to the private sector and universities, and privatizing more government research.

The debate is not about objectives. Virtually everyone recognizes the importance of good science. Similarly, there are few disagreements over means such as better cooperation between sectors or transfer of more technology. The debate centres on how to organize government and private research so as to accomplish S&T objectives.

Those advocating a larger role for industry propose that all but mission-related government research be contracted out. More government-industry-university joint contracts, industry secondments and exchanges, and research fellowships would take place. The sale, transfer, or devolution of research facilities or systems from the public to the private sector would be encouraged.

Privatizing government research obviously becomes a means to achieve S&T objectives. But the question remains: when does it make sense to privatize and when does it not? For example, the amount of S&T done by the public sector depends on a department's mandate and the economic structure and capabilities of private industry. What then is the best way to divide the S&T tasks relevant to DFO among the major players: governments, industry, educational institutions, and non-profit research institutions?

In some circumstances, privatization of public sector research may not be the most efficient way to organize some of the essential S&T. For example, DFO's mandate requires it to produce many different types of public goods, such as safety at sea, marine pollution control, and fisheries management, which depend upon advances in targeted basic research. Most often, only DFO requires the information from this research. If the research were privatized, DFO would be the only client. In other circumstances, such as where DFO's mission-related research leads into areas where commercial spinoffs are possible, good public sector management would warrant contracting that research to private firms.

However, in practice, it is often difficult to forecast commercial potential arising from scientific projects, and to know when to privatize research and when to conduct it in-house. Although a definitive answer to the question of when to privatize is not possible, it is possible to describe examples of actions that illustrate how economic, technological and industrial growth is encouraged by DFO. DFO's scientific activities are essentially designed to accomplish the department's mission. In addition, they can also contribute substantial benefits and even leadership to S&T in other sectors. When this happens, an appropriate balance between public and private sector research is achieved.

Organization of DFO's Scientific Activities

DFO's scientific research is organized to facilitate its mission with respect to ocean and freshwater fisheries, hydrographic and marine sciences and coordination of the policies and programs of the Government of Canada respecting oceans. DFO has research facilities across Canada. The major centres are the Institute of Ocean Sciences (IOS), the West Vancouver Laboratory and the Pacific Biological Station (British Columbia), the Freshwater Institute (Manitoba), the Bayfield Laboratory (Ontario), the Arctic Biological Station and the Maurice Lamontagne Institute (Quebec), the Gulf Fisheries Centre and the St. Andrews Biological Station (New Brunswick), the Bedford Institute of Oceanography and the Halifax Laboratory (Nova Scotia), and the Northwest Atlantic Fisheries Centre (Newfoundland). Each centre specializes in several areas.

Science activities within each research laboratory are organized along disciplinary lines into biological sciences, physical and chemical sciences, and hydrography. Multidisciplinary teams are deployed to address key research problems which cut across the basic areas of specialization.

Biological science covers areas such as resource assessment, parasitology, genetics, biotechnology, aquaculture, marine ecology, and study of fish habitat together with the operation of Atlantic hatcheries. These types of research are required to fulfill the department's mandate to manage the fisheries, fish habitats, and aquaculture. Physical and chemical sciences cover research on the oceans, including the influence of the oceans on fish stocks, the atmosphere and climate. It also includes toxicology and contaminants science relating to both marine and freshwater environments. The research often requires instrumentation and information technologies such as remote sensing and submersibles, many of which are developed jointly with industry. Much of the work carried out by oceanographers assists offshore oil and gas development and is vital to coastal protection, pollution control, environmental forecasting and navigation. Hydrographic research and development are carried out to improve the ability of the Canadian Hydrographic Service (CHS) to chart navigable waters and measure currents and tidal phenomena. Hydrographic charts facilitate commercial navigation and fishing activities, and assist offshore development.

Structure of this Report

Section II of this report describes the economic importance of the oceans sector and highlights the oceanic manufacturing and services industry; Section III compares DFO's S&T activities to those of other federal departments and sectors, and presents DFO science employment and technology transfer effects; Section IV identifies benefits from scientific activities carried out at BIO and IOS and describes selected economic benefits from DFO's biological science; and Section V presents the major conclusions of the study.

Notes on methodology and tables of data are provided in the appendices. For further details about case studies of relationships between DFO science, companies, products and industries see the companion report to this study entitled *Fisheries and Oceans Research Centres: Cases of Technology Transfer*.

Section II

The Economic Importance of the Oceans Sector

This section briefly describes the importance of ocean industries to Canada's economy, and the importance of DFO's scientific activities to the oceans sector.

Selected data on the oceans sector from the 1987 DFO report, *Canada's Oceans*, are presented below. They show that this sector is directly responsible for more than $8 billion of Canada's national product and more than 140,000 jobs. Figure II-1 shows the relative outputs of the various components of the oceans sector. Table II-1 presents estimates of current gross expenditures and employment for selected oceans sector industries. Commercial fisheries, for example, are valued at more than $2.4 billion and employ over 100,000 fishermen and plant workers.

Table II-1:
Estimated Output and Employment for Selected Oceans Sector Industries in 1985 (1985 Canadian dollars)

Industry	*Output or Expenditure ($ billions)* 1985	*Employment[a] (thousands)* 1985
Primary Industries		
Fisheries[b]	2.4	100
Oil and gas[c]	2.0	9
Marine Shipping[d]	2.3	17
Support Industries		
Shipbuilding and Repair	1.0	11
Oceanic Manufacturing and Services	0.3	6

[a] Full-time and seasonal jobs (e.g., fisheries) are shown — not necessarily an estimate of person-years.

[b] Preliminary estimate including production from commercial sea fisheries and aquaculture (excluding saltwater recreational fisheries with attributable expenditures of $402 million).

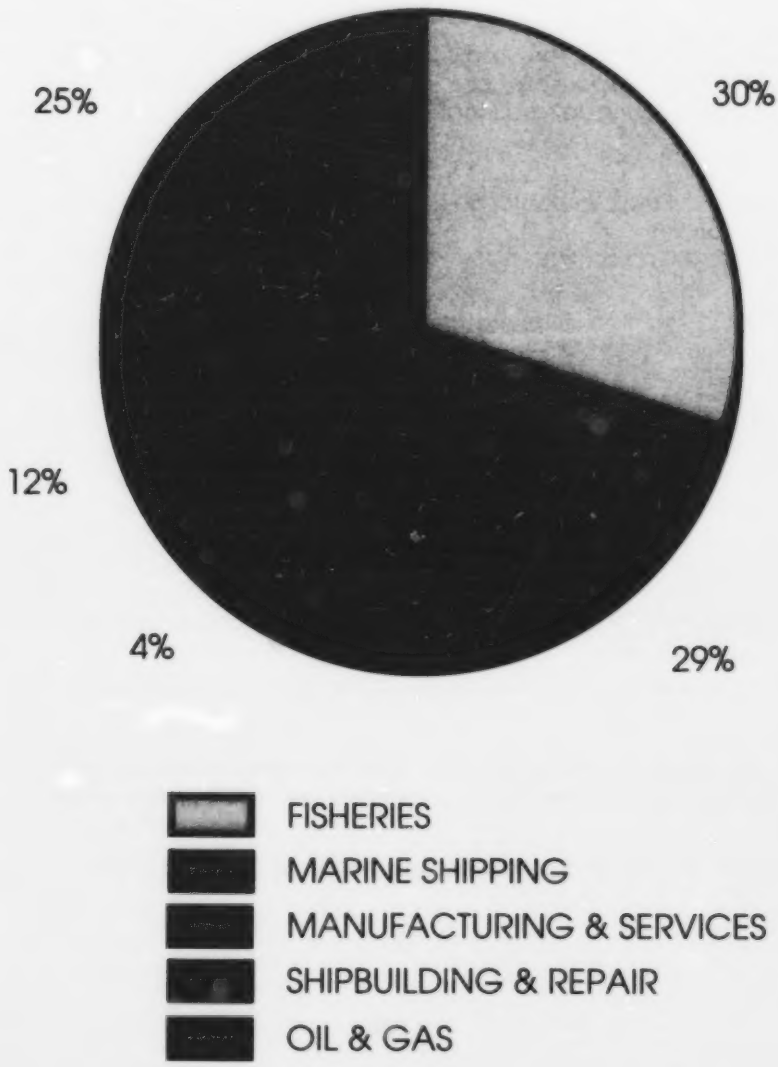
[c] Output related to oil and gas within the jurisdiction of Canada Lands.

[d] 1984 data.

DFO's scientific research directly affects the commercial fishing, marine shipping, offshore hydrocarbon, shipbuilding and repair, and oceanic manufacturing and services industries. DFO's science contribution to all but the oceanic manufacturing and service industries is well known. For example, most of those who participate in the national debate on S&T are aware that the wholesomeness of fish, pollution-free waters and safety at sea are directly related to DFO's scientific research.

FIGURE II-1

OCEANS SECTOR VALUE OF OUPUT BY INDUSTRY, 1985



DFO's contribution to the oceanic manufacturing and services industry is less understood, and the subject will be treated in detail in the following sections. This dynamic group of companies, in spite of its relatively small size, provides critical support and an infrastructure to the entire oceans sector. Its rapid growth over the past 10 years is explained by a number of factors: commercial opportunities created by the establishment of national institutes in marine fisheries, environmental and resource sciences and engineering; government contracts and S&T spending; and in particular, offshore oil and gas exploration activities.

There are currently about 520 companies forming the oceanic manufacturing and service subsector in Canada. These provide approximately 6000 direct jobs and have gross sales in excess of $270 million (1986). The majority of these firms are small, employing from 5 to 25 people, and have sales as high as $10.0 million.

In British Columbia there are about 120 firms with gross sales totalling $100 million, employing about 1200 people in 1986. In the Atlantic provinces, about 200 firms, employing about 2600 people, had sales in excess of $90 million.

The manufacturers have products, systems and software for oceanographic, hydrographic, diving and other operational marine applications, for marine-related remote sensing, submersibles and seabed systems. The service subsector covers a wide range of activities based in engineering, sciences, consulting and surveying, including aerial surveying with marine applications. Most of these companies employ advanced technologies. Many of them also develop or adapt advanced technologies, systems and software for innovative applications.

Governments are often the most important customers for these companies. In addition to direct purchases of goods and services for specific programs, federal funding of private sector S&T is a significant factor in the financial health of participating firms, and government contracts stimulate a wide variety of innovations in ocean-related products, systems, software, services and techniques. These are applied in Canada and, in many cases, result in successful export activities. For example, the Computer-aided Resource Information System (CARIS), was developed by DFO and transferred to Universal Systems Limited (New Brunswick). The CARIS is sold in Germany, the Netherlands, Egypt, and Australia.

The domestic offshore exploration industry is the second-largest customer for Canadian oceanic industry products and services. Its decline in the mid-1980s led to a sharp reduction in private sector demand in the oceanic manufacturing and services subsector.

The growth of Canadian oceanic manufacturing and services is related to international conditions. For example, the extension of national jurisdictions to 200 miles placed new emphasis on ocean resource management, thus encouraging ocean sector growth internationally. Such management requires first-rate technologies and sustained scientific effort. A reversal in the present world decline in offshore exploration activities would also increase this sector's potential for expansion.

Section III

National Indicators of Effects of DFO Science

The data on Canadian S&T activity presented in this section refer to two categories of science expenditures: research and development (R&D) and related scientific activities (RSA). R&D is research and technological development. DFO carries out R&D in support of its mission. Technological development focuses on instruments, vehicles, and methods needed for departmental programs. Where appropriate, technology is transferred to Canadian industry. About 35 per cent of science program expenditures in 1987-88 are on RSA, and surveying and monitoring are the primary related scientific activities.

Canadian S&T Patterns

Most of the $6.53 billion in total Canadian S&T expenditures (1985) are spent in Central Canada. The data provided in Figure III-1 on their regional distribution show that about 80 per cent of the S&T expenditures by all sectors are in Central Canada. Figure III-2 shows that more than 80 per cent of the S&T conducted solely by the private sector is done in Central Canada, and fully three-quarters of this is done in Toronto, Montreal and the National Capital Region. The private sector conducts very little S&T in the Atlantic provinces, and undertakes more S&T in Montreal than in all of Western Canada.

Although the private sector performs and funds more Central Canadian S&T than does the federal government, in other regions the federal government usually funds and performs more S&T than the private sector. Figure III-3 shows that the federal government funds over 70 per cent and performs over 50 per cent of all Atlantic S&T. This regional pattern is also observed when per capita expenditures are compared (see Figure A-1, Appendix I).

Seventeen federal departments and agencies fund S&T, but only six both fund and perform S&T. Agriculture, Fisheries and Oceans, Environment, Defence, the National Research Council and Energy, Mines, and Resources perform mission-related research. It is with respect to these six federal S&T performers and funders that the privatization question pertains.

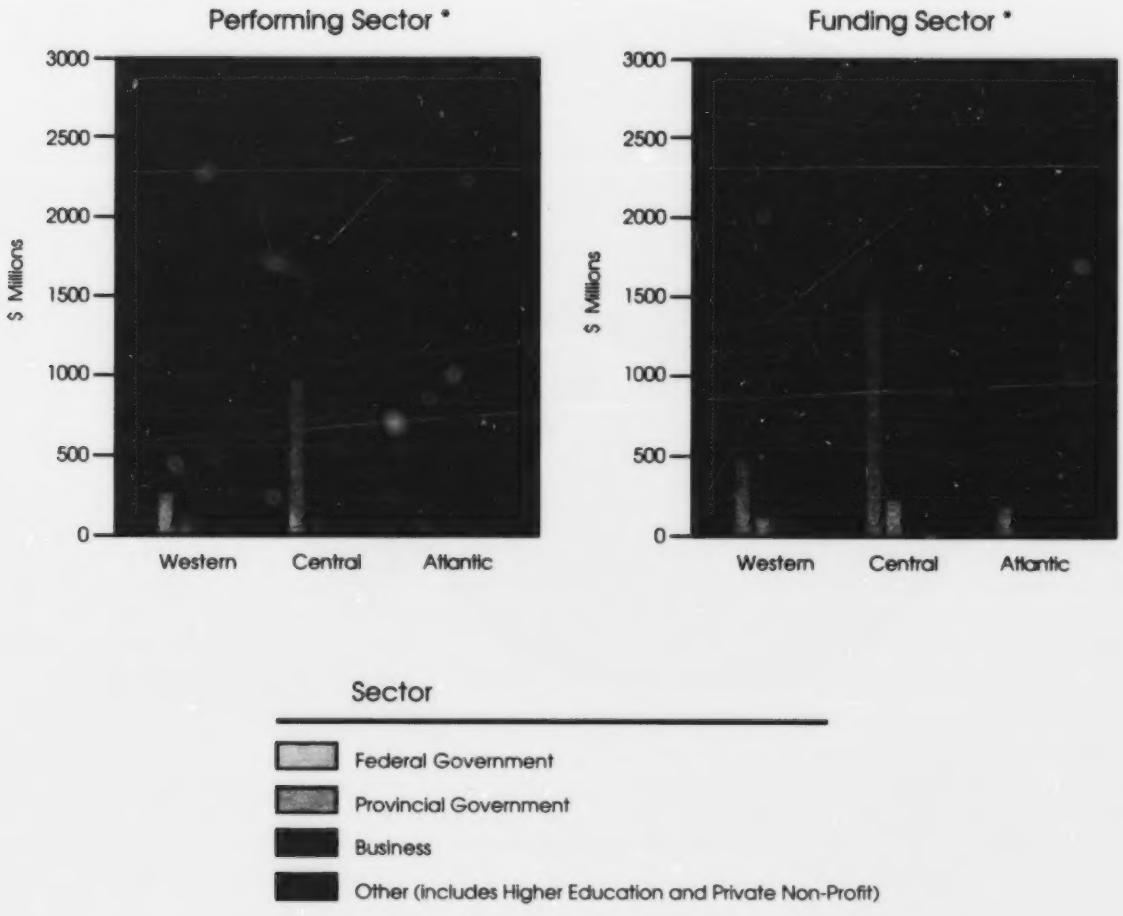
Science expenditures by the six federal S&T funders and performers support science-based industries, and DFO is a major contributor to federal S&T expenditures in the Atlantic provinces and in British Columbia. In fact, Figure III-4 shows that DFO is the only department that spends the highest proportion of its total science budget outside Central Canada. While some departments spend as much as 80 per cent of their in-house S&T budgets in Central Canada, DFO spends only 30 per cent.

DFO's extraordinary contribution to regional economic development results in part from the way its science activities are organized; DFO science is decentralized because scientists need to be close to the problems they research. Fortunately, this decentralization has a major effect on regional economic, industrial and technological growth.

In comparison with the other federal science funders and performers, DFO was the second-largest source of extramural science contracts between 1982 and 1987. DFO contracts had an average value of $35 million per year, while the highest (EMR) was $58 million per year (see Figure A-2, Appendix I).

FIGURE III-1

REGIONAL DISTRIBUTION OF CANADIAN S&T EXPENDITURE BY SECTOR, 1985

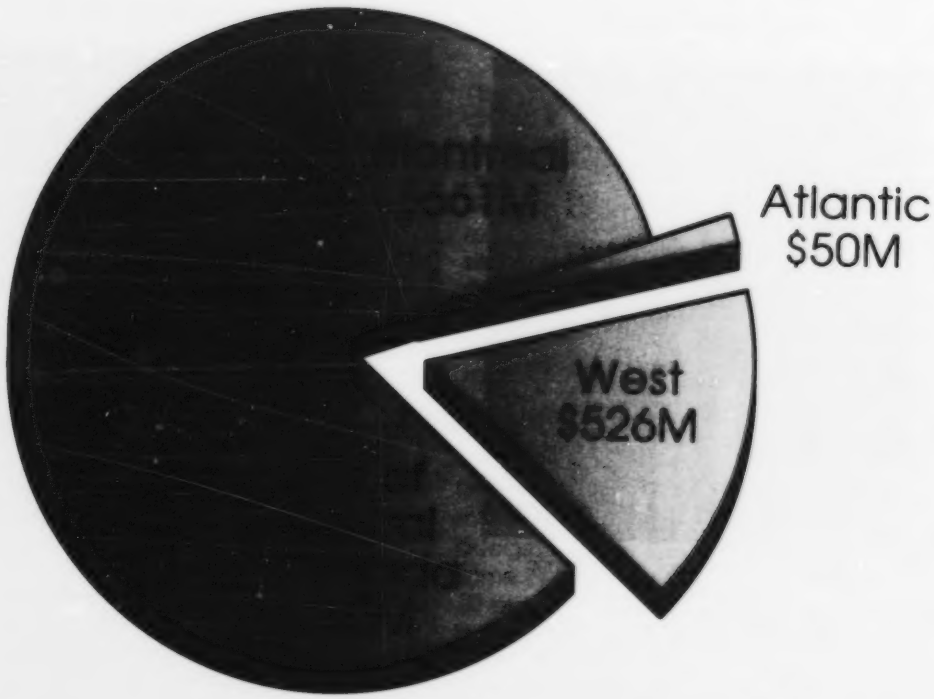


* Performing sectors conduct S&T; funding sectors provide financial support to others who conduct S&T.

Source: Statistics Canada. Cat. 88-201

FIGURE III-2

BUSINESS SECTOR S&T EXPENDITURE BY REGION, 1985

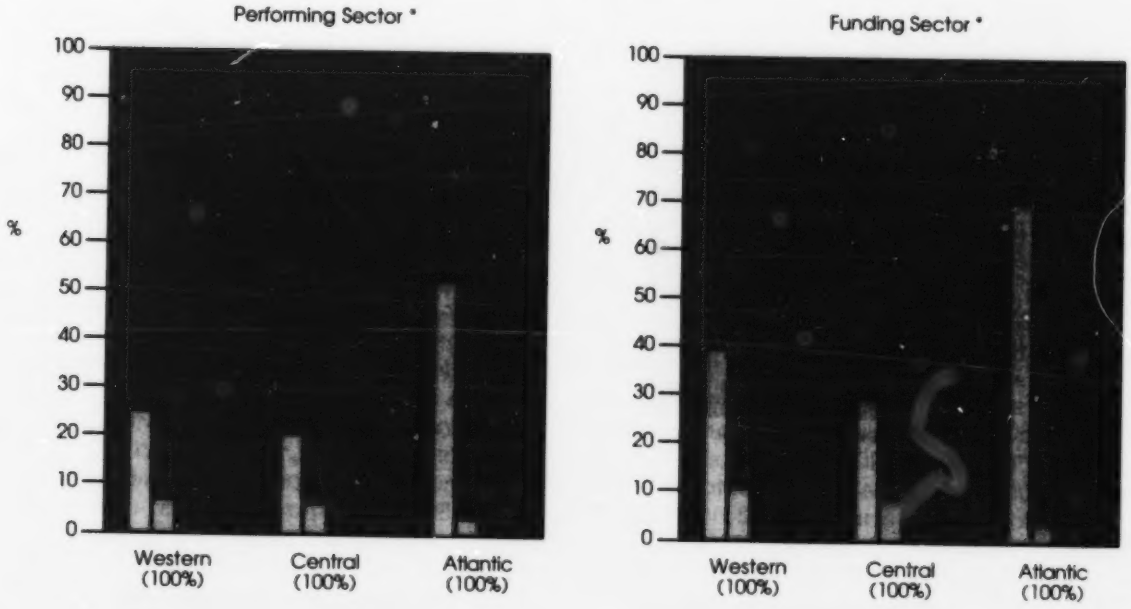


Total = $3,330M

Source: Statistics Canada. Cat. 88-201

FIGURE III-3

INTRA-REGIONAL COMPARISONS OF SECTOR S&T EXPENDITURES AS A PERCENTAGE OF TOTAL REGIONAL S&T EXPENDITURES, 1985

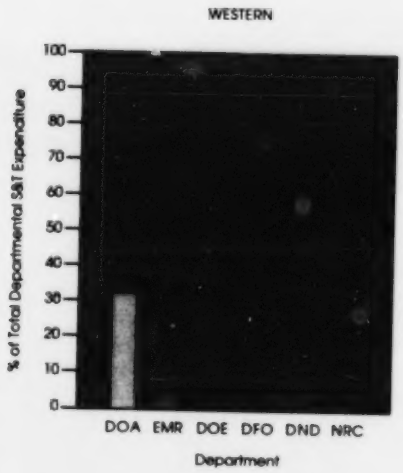


* Performing sectors conduct S&T; funding sectors provide financial support to others who conduct S&T.

Source: Statistics Canada. Cat. 88-202

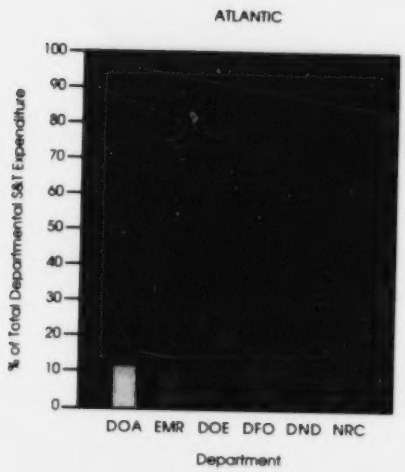
FIGURE III-4

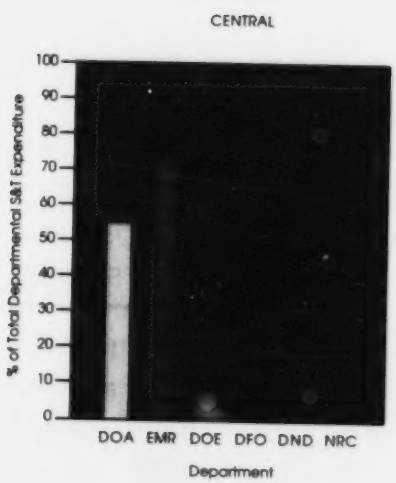
REGIONAL INTRAMURAL S&T EXPENDITURE AS A PERCENTAGE OF TOTAL S&T EXPENDITURE BY SELECTED FEDERAL DEPARTMENT, 1984/85



Legend

DOA = Department of Agriculture
EMR = Energy, Mines and Resources
DOE = Department of Environment
DFO = Department of Fisheries and Oceans
DND = Department of National Defence
NRC = National Research Council





Source: Statistics Canada. Cat. 88-204

Furthermore, Figure III-5 shows that DFO let more contracts per year over this five-year period than the other federal departments. On average, DFO was the scientific authority on more than 1000 science contracts each year.

The federal government's Unsolicited Proposal (UP) program is highly regarded by the private sector and DFO is a consistent supporter of this program. UP data covering a five-year period confirm the pattern noted above (see Figure A-3, Appendix I). Descriptions of some of the many technologies started with UPs involving DFO are provided in the companion report to this study.

DFO funded significantly more business sector S&T, as a percentage of its extramural payments, than did the federal government considered as a whole. Analysis of 1985/86 DFO extramural science contracts (including both R&D and RSA), shows that 80 per cent of DFO's extramural payments went to industry and only 14 per cent to universities (see Table A-4, Appendix III). DND and MOT R&D payments to industry are also high. However, Statistics Canada data on Canadian resources for research and development for 1984 show that 40 per cent of all federal payments for S&T went to private industry, 55 per cent to institutions of higher education, and the remainder to provincial governments and private non-profit sectors.

Figure III-6 shows that DFO is a significant user of other sources of funds, receiving from other sources about one-third of its funding for extramural science contracts between 1984 and 1987. However, A-base reductions are affecting the department's capacity to contract out, since discretionary funds are always the most susceptible to cutbacks.

Employment and Technology Transfer

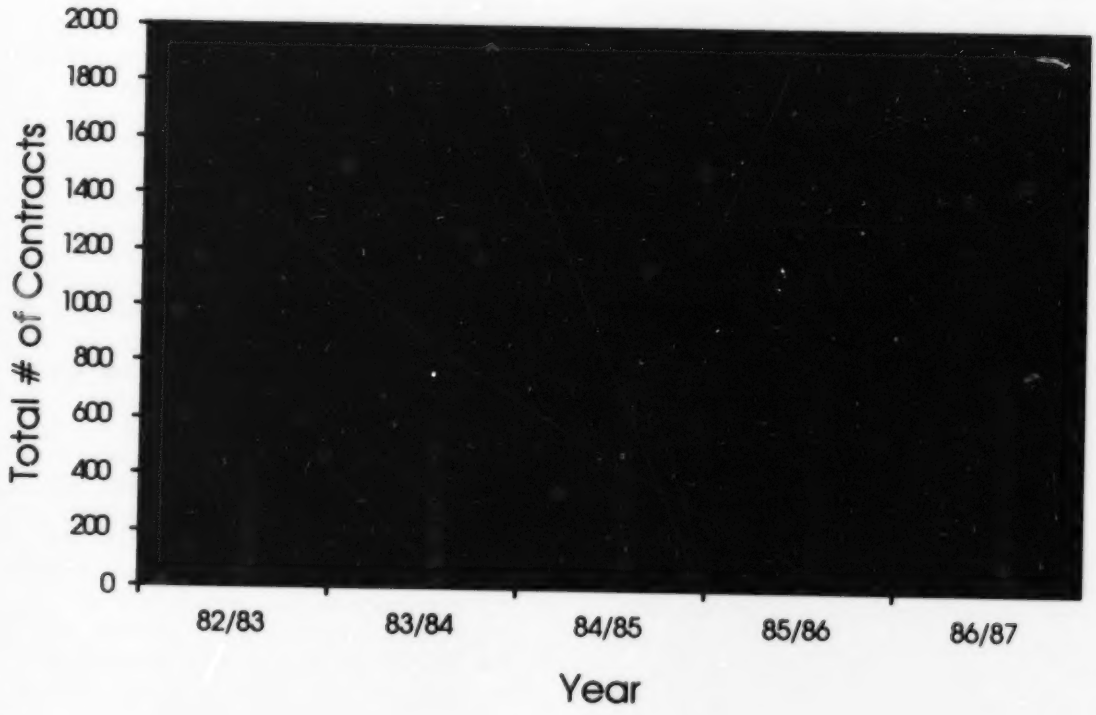
Although DFO's science activities are designed to meet the department's needs for information about the oceans and their resources, the work of DFO's scientists profoundly affects regional economic growth and development.

There were 2342 person-years divided among 38 communities across Canada, devoted to DFO science in 1985/86. Figure III-7 shows the location of communities with DFO science PYs; the sites vary in population from Metropolitan Toronto (3.3 million), to Miramichi, New Brunswick (66). Communities where DFO has a science presence are listed in Table A-3, Appendix II.

Spinoff effects from expenditures on wages and S&T contracts at DFO science centres created an estimated 6621 jobs within the provinces where centres are located, and up to another 5160 jobs across Canada (see Table A-4, and the discussion of how these effects were determined in Appendix III). A total of 14,123 PYs, including DFO science PYs, were created by DFO expenditures on wages and S&T contracts at research centres in 1985/86. One indicator of the significance of these employment effects is a comparison of the number of DFO science PYs at the research centres with the number of spinoff jobs. On average, each DFO PY was associated with five other jobs in the Canadian economy. In some cases, such as BIO and IOS, one DFO PY was associated with over four other PYs while in other cases, such as Maurice Lamontagne Institute, the ratio was higher. Fully two-thirds of the estimated spinoff jobs were in regions most in need of economic development.

FIGURE III-5

TOTAL NUMBER OF SCIENTIFIC CONTRACTS PER YEAR, BY GOVERNMENT DEPARTMENT, 1982/83 TO 1986/87



DFO
DND
DOE
EMR
NRC
DOC

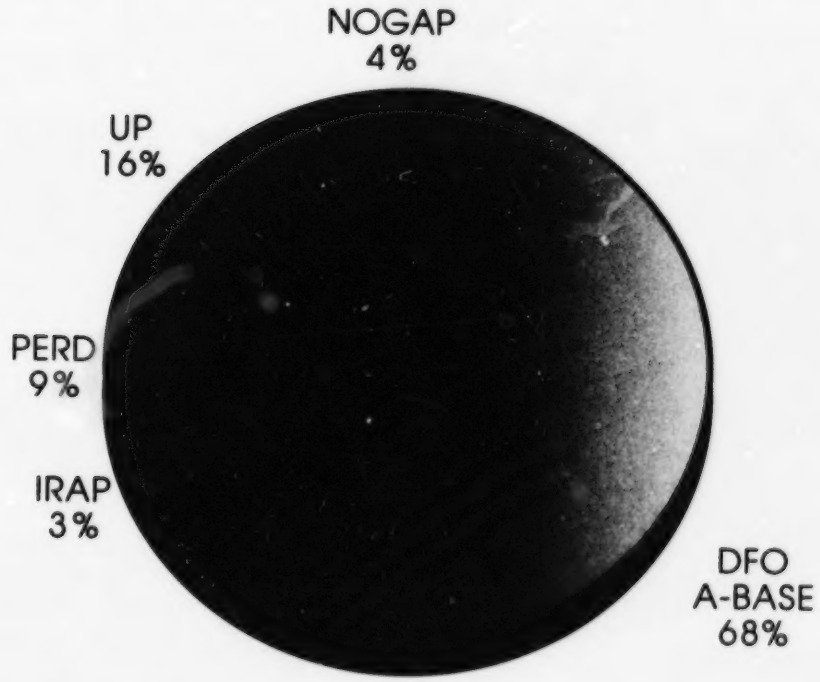
Legend

DFO = Department of Fisheries and Oceans
DND = Department of National Defence
DOE = Department of Environment
EMR = Energy, Mines and Resources
NRC = National Research Council
DOC = Department of Communications

Source: Supply and Services Canada. Research and Development Bulletin

FIGURE III-6

TOTAL VALUE OF DEPARTMENT OF FISHERIES AND OCEANS SCIENCE CONTRACTS BY FUNDING SOURCE 1984/85 TO 1986/87



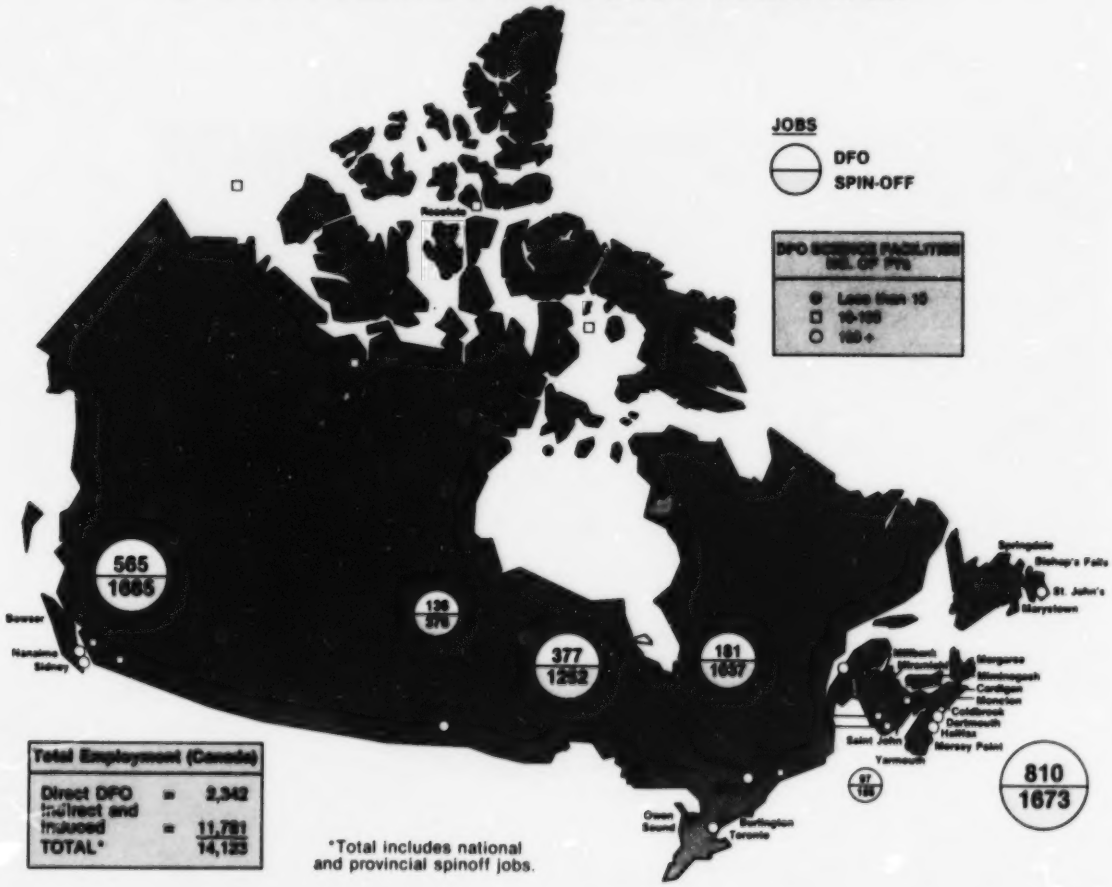
Total = $112.2M

100% MISSION-ORIENTED

IRAP = Industrial Research Assistance Program
NOGAP = Northern Oil and Gas Action Program
PERD = Panel on Energy Research and Development
UP = Unsolicited Proposals

FIGURE III-7

DFO EMPLOYMENT IN COMMUNITIES WITH MAJOR DFO SCIENCE RESOURCES AND ESTIMATED SPINOFF EMPLOYMENT BY PROVINCE 1985/1986



DFO Science also contributes jobs specifically related to technology transfer. For example, under the Industrial Research Assistance Program (IRAP), six technologies developed by DFO were successfully transferred to the private sector over the past four years.

Although there are some exceptions, most technologies transferred out of DFO and commercialized are small inventions that reach markets without going through the patenting process. This occurs partly because the firms are too small to afford potential legal fees, and partly because their inclination is to develop their competitive edge, which in most cases is only a year or two, rather than to defend it. Since most of DFO's transferred technology is thus not reflected in the records kept by Canadian Patents and Development Ltd., their data on licensed inventions are not indicative of the amount of technology transferred out of DFO.

DFO's transfer of technological knowledge is illustrated by post-doctoral fellowships held at DFO. Every year, about 30 scientific fellows work at DFO science facilities. They import knowledge and gain experience, which they take with them to other institutions and sectors. Analysis of 16 Canadian fellowships between 1984 and 1987 revealed that six joined DFO, two joined other federal departments, two entered the private sector, five went to Canadian universities, and one took a position in a foreign country.

Summary

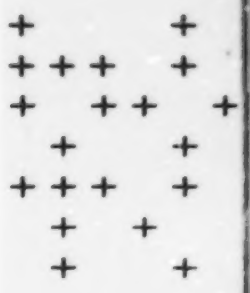
DFO's scientific activities have major effects on Canada's economic, technological, and industrial growth.

Five PYs of Canadian employment are associated with each PY at a DFO research centre. At least 65 per cent of these other jobs are in the Atlantic provinces and British Columbia. DFO's research centres are decentralized, and their expenditures benefit the regions most in need of economic, technological, and industrial development.

DFO is second only to EMR in the value of science contracts, and second-to-none in the number of contracts. These results are accomplished by supplementing A-base funds with funds solicited from other departments. Almost one-third of all DFO science contract dollars are provided by other departments.

Eighty per cent of DFO's extramural payments are to industry, which receives only 40 per cent of total federal extramural payments. By directing most of its contracts to private firms, DFO maximizes the possibility that science contracts will lead to commercial sales. The contracts are often a step in the process of technology transfer, initiating or developing a firm's capability to provide goods or services.

Many technologies are successfully transferred to other sectors by DFO science activities. Analysis shows, for example, that scientific knowledge is transferred by training post-doctoral fellows, many of whom enter other sectors.



Section IV

Effects of DFO's Major Research Centres

This section provides details of economic, technological, and industrial spinoffs from DFO science activities at its two largest centres: the Bedford Institute of Oceanography and the Institute of Ocean Sciences. The major areas covered at these centres are hydrographic and oceanographic research. In both the Pacific and Scotia-Fundy Regions, a significant amount of biological research is undertaken at other DFO laboratories. For this reason, a discussion of benefits to the fishing industry from biological science conducted at other DFO laboratories in the Pacific and Scotia-Fundy regions is also provided.

The two institutes were selected for detailed investigation for several reasons other than their size: each has a history of more than 10 years of activities; their differing emphases are descriptive of many of DFO's scientific activities; each has a world-class reputation; and each is representative of one of Canada's two largest coastal regions.

The effects that such centres have on regional S&T and economic development are well known. Complexes of non-profit research institutions, including universities, technical colleges and government research establishments, along with science-based manufacturing firms, tend to develop in close proximity. Under ideal circumstances, this creates a system of scientific infrastructure that results in centres of excellence. The performance of science-based firms is strongly influenced by proximity to such laboratories. Marketing costs can be reduced since communications between buyer and seller are facilitated. Ideas are exchanged. A highly skilled labour force clusters at that location. Risk capital can be more readily obtained since financial institutions in the area are familiar with individual situations. Access is provided to facilities that may be beyond the cost of individual firms.

Centres of scientific and technological excellence spin off new firms; in some cases they are started by former government employees. Firms are often supported over a critical take-off period by contracts, expertise and access to facilities at the centre. Small, technologically intensive firms use the benefits they gain from close contact with large scientific laboratories to compete successfully with other firms.

The Bedford Institute of Oceanography

BIO and Industry Growth

In 1978-79, only 25 oceanic manufacturing and service firms operated near Halifax-Dartmouth. Apart from the two largest firms there were about 100 employees working in 23 firms. By 1986, and again excluding the two largest, there were 58 firms employing 1000 people. Employment in these small companies increased tenfold.

Until 1981, BIO conducted most of its research in-house. By 1983, BIO was the most important supporter of local oceanic firms in the region.

Contracting levels rose rapidly after 1981 due to the combined effects of a number of factors. In the early 1980s, ocean scientists around the world were producing technologies which increased researchers' capacity to do applied studies. Offshore hydrocarbon exploration activity demanded more applied studies, as did the interest in resources within the 200-mile zone.

During this period DFO also received significant increases in research funds through the Panel on Energy Research and Development (PERD). DFO and previously Energy, Mines and Resources (Mines and Technical Surveys), had been implementing a long-term strategy to build Canadian private sector expertise in marine sciences and hydrography. In addition to the above, the "Make or Buy" policy and the Unsolicited Proposal and associated programs also helped to make BIO the most important supporter of oceanic firms in the region by 1983.

Seimac Limited of Nova Scotia is an example of the kind of support that the Institute was able to provide to private firms by 1983. Started in 1978 with two employees, the Seimac group of companies grew into three separate firms with 36 employees. In the case study of SEIMAC, found in the companion report, Hugh McPherson (Vice President, Seimac Industries) stated that " . . . DFO/BIO contracts from 1982 and 1984 were very important in carrying the firm through the recession period and allowing it to emerge in relatively sound financial condition." Those contracts moved Seimac into longer term development projects, helped it to develop more sophisticated project management methods and gave it the expertise required to obtain DND Arctic defence contracts. For a more complete discussion of interactions between DFO and Seimac, see case number three in the companion study.

One reason for BIO's importance to private firms is that it is the largest employer of scientists in the area. Table IV-1 shows research centres relevant to DFO science and their associated person-years (PYs).

Table IV-1:
Nova Scotian Research Centres and Associated Person-Years, 1987

Research Centres	*PYs (1987)*
DFO Science Facilities	
Bedford Institute of Oceanography	447
Halifax Lab and Hollis Street Building	135
National Research Council (Atlantic Lab)	76
Technical University Nova Scotia	300
Nova Scotia Research Foundation	119
Defence Research Establishment	200
Dalhousie University	
Oceanography	50
Biology	203
School for Environmental Studies and Marine Affairs	20
Atlantic Geoscience Centre*	125
Total	**1,675**

* Also located at the Bedford Institute of Oceanography, but not part of DFO.

The accumulated knowledge and synergy available to its scientists also explains why the Institute catalyzes private firms. While academic institutions possess synergy and knowledge, they encourage less economic growth because they emphasize training, not commercialization of outputs.

As a world-class centre of excellence, BIO attracts firms with similar scientific interests. For example, a DFO study of oceanographic firms in Halifax-Dartmouth showed that the number of such firms increased eightfold between 1981 and 1984, when the factors described above combined to facilitate greater Institute involvement in other sectors. Employment rose from 20 to 170, revenues from $1.2 million to $9.8 million, and the number of companies grew from two to 16.

The typical company was incorporated in 1982 and in 1987, had 10 employees, of whom 6 were scientists or engineers, 3 were technicians, and 1 an administrator. Gross revenue was about $0.6 million, about $60,000 per employee. In total, 100 out of 170 employees were scientists or engineers, 43 were technicians, and 27 were administrators.

About one-third of the firms were started by former employees of the Institute and over 10 per cent of their employees were former public servants (20 out of 170). Former public servants started Seimac and OceanRoutes, for example, and 5 of their 36 employees were former public servants.

BIO supported 11 of the 16 firms with contracts between 1983 and 1985. Almost 10 per cent of their total 1986 revenue came from contracts with the Institute. Financial dependence was not encouraged. In only three cases were Institute contracts more than eight per cent of the total revenue of these firms.

These analyses describe some of the Institute's influences on local economic, technological and industrial growth. However, BIO's effects are far more wide-ranging. The following analysis of effects on those to which the Bedford Institute let science contracts between 1983 and 1985 sheds more light on the importance of this centre to regional and Canadian economic development.

Contracting Out at BIO

The following analysis of financial and non-financial support understates the contributions made by BIO to other sectors because it only refers to contractual relations with these sectors. The Institute constantly interacts with all sectors and continues to do so after projects are finished. However, data on interactions outside contract situations were not available. Although the analysis is restricted to formal, contractual situations, it is helpful in revealing minimum levels of financial and other types of support provided by the centre. This type of information bears on the question of whether DFO scientific activities effectively balance public- and private-sector roles in S&T.

The contractual relationships are described in terms of their dollar value and other benefits received over the course of the contract. Information on the percentages later converted into commercial benefits completes the analysis.

BIO let more than 250 contracts involving over 100 different firms between 1983 and 1985. Eighty-five per cent of these contracts were in the Atlantic provinces, but because four contracts, (each over $1 million), went to British Columbia firms, only 55 per cent of the contracts in terms of value were with Atlantic province firms. The Institute spent over $7 million each year on contracts, one-third of which produced tangible commercial spinoff benefits for the firms. Each year DFO's non-financial support (which half the contractors received) had an estimated value of over $1 million.

Direct S&T Support

The Institute managed contracts involving 101 firms over the three-year period. This was about one-half of all oceanic manufacturing and service firms in the Atlantic provinces. Only two contracts were with non-Canadian firms. These data provide clear evidence of DFO's ongoing commitment to enhancing Canadian technological expertise.

Examples of the types of products developed through contracts include a high-speed shipboard winch, a means of drafting Loran-C lines-of-position lattices on navigational charts and a computer program incorporating Loran-C lattices on charts, a portable salinometer, and hardware and techniques for recovering moorings at sea. More examples of oceanographic and hydrographic contracts are contained in working papers number seven and eight in the companion report.

The contracts had a total direct value of $21.6 million. Table IV-2 shows that on average, oceanography represented 55 per cent of total contract value and hydrography accounted for 36 per cent.

Table IV-2:
BIO Technology Transfer Contracts, 1983 to 1985, by Science Sector (Annual Average)

Science Sector	*Number of contracts*		*Value of contracts*	
	No.	*% of total*	*$000*	*% of total*
Oceanography	29	35	136	55
Biological Science	34	41	19	9
Hydrography	20	24	131	36
Total	**83**	**100**	**87**	**100**

An initial reading of the data showing the regional distribution by value of the contracts suggests that the Institute's effects are nation-wide. Forty-five per cent of the value of the contracts went to firms and other sectors outside the Atlantic provinces. However, a more detailed analysis suggests that the main effects of the contracts would normally be experienced within Nova Scotia. Table IV-3 shows the number of contracts and their direct value by region.

Although 55 per cent of the contract value went to the Atlantic provinces, all but five per cent of this went to local Nova Scotian firms. The Institute's contracts tend to affect Nova Scotia and British Columbia sectors more than sectors in other regions.

Table IV-3:
BIO Technology Transfer Contracts, 1983 to 1985, by Region (Annual Average)

Region	*Number of contracts*		*Value of contracts*	
	No.	*% of total*	*$000*	*% of total*
Western	7	9	400	38
Central	3	4	140	6
Atlantic	72	86	55	55
Foreign	1	1	60	1
Total	**83**	**100**	**87**	**100**

Thirty-eight per cent went to sectors in the Western provinces, but this high proportion is a result of a few large contracts.

BIO let four contracts between 1983 and 1985 valued at over $1 million. Two UP contracts of over $1 million each went to a British Columbia firm in successive years, for development of the Deep Ocean Logging Platform with Hydrographic Instrumentation and Navigation (DOLPHIN). This hydrographic system improves depth-sounding coverage. (See the case of the DOLPHIN in the companion study.) The other two contracts of over $1 million were to a firm in British Columbia for hydrographic surveys of Foxe Basin.

It is important to know if DFO's mission-oriented contracts with other sectors also were successful at transferring technology. Do private firms convert the experience they gain from DFO contracts at the Institute into commercial benefits? Table IV-4 below shows that fully one-third of the contracts had tangible benefits:

Tangible benefits include hardware, software, and products or services. Intangible benefits include benefits which increase the expertise of a firm and

Table IV-4:
BIO Technology Transfer Contracts, 1983 to 1985, by Type of Benefit (Annual Average)

Benefit Type	*Number of contracts*		*Value of contracts*	
	No.	*% of total*	*$000*	*% of total*
Tangible	29	35	82	33
Intangible	54	65	90	67
Total	**83**	**100**	**87**	**100**

thereby help to place it in an advantageous position for other work. Although these benefits are less concrete than tangible ones, they are valuable. For example, the Institute transferred a pumping system for extraction of chemicals from seawater to Seastar Instruments Limited by means of a contract. As a result of this transfer, the company gained expertise in this area (intangible benefit), markets the pumping system as a stand-alone device (tangible benefit) and now provides a complete monitoring service of associated analytical support (tangible benefit).

Non-Financial S&T Support

More than half the contracts issued from 1983 to 1985 at the Institute included non-financial support. The value of this support is often a significant proportion of costs. It includes such items as ship time, use of laboratories, library and computer facilities, and scientific and technical advice. This support had a total annual value of $1.36 million, slightly less than 20 per cent of the annual direct value of contracts (see Tables A-6 and A-7, Appendix IV). Three-quarters of the non-financial support went to Atlantic firms. Oceanographic contracts accounted for over 50 per cent, biological science 30 per cent, and hydrography about 20 per cent.

The value of the non-financial support frequently exceeded the direct value of the contract. Firms received more non-financial assistance when new hardware, software or services were being developed than at later stages of their development, demonstrating a support policy that assists firms through transfer of technology without creating financial dependence.

The Seimac-BIO relationship illustrates one form of non-financial support. Seimac placed two staff members within the Institute's laboratories to learn about BIO's oceanographic instrument calibration and maintenance technology. In another case, a Seimac engineer worked under the supervision of an Institute scientist for one year and gained expertise on oceanographic data buoys.

Another example is that of the DOLPHIN. The Institute also provided several forms of non-financial support, including ship time for DOLPHIN sea trials. (See case number eight in the companion study for more examples and illustrations of types of non-financial support.)

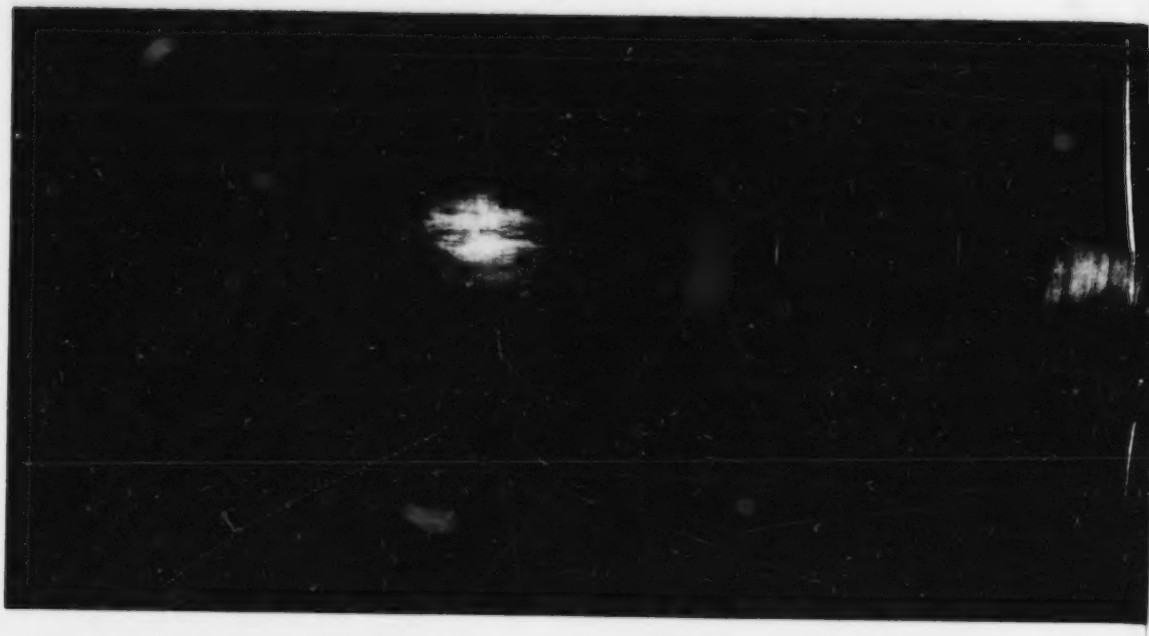
Institute of Ocean Sciences

This section examines the economic and technological benefits that result from interactions between IOS and other sectors in British Columbia. IOS is the only significant oceanographic science centre in the province with strong linkages to other sectors. The Pacific Defence Research Establishment carries out similar research, but for security reasons does most of its research in-house. Fewer than 50 scientists are employed in relevant oceanic fields at the University of Victoria, Simon Fraser University and the University of British Columbia. B.C. Research employs about 120 people, but many of these employees do applied research in other areas.

To a large extent, Institute contracts created the west coast oceanic manufacturing and services industry. Few oceanic manufacturing and service firms existed on Vancouver Island, and only a few were on the mainland before IOS was founded in the early seventies. Since the opening of IOS occurred at the same time as the implementation of the federal "Make or Buy" policy a considerable amount of IOS research was contracted out to support this policy.

A good example of the stimulus the Institute provided is the Seakem group of companies. The founding company was started in 1974 by three graduate students who worked at IOS and saw commercial opportunities from their work. Working closely with the Institute on a number of contracts helped the company to grow from three individuals in one company to seven firms with 100 employees and $5 million in gross sales. (See the case of Seakem in the companion study.)

As shown by a selected sample of 38 firms, the growth of the firms around the Institute was rapid. In the eight years prior to 1985, gross sales doubled every two years, and personnel doubled every three years. Between 1985 and 1987, the gross sales of these companies stabilized at $21 million. In spite of the collapse of the



oil industry and a plateau in federal science contracting, total revenues of this dynamic group of companies did not decline.

In 1987, 11 local companies had sales in excess of $1 million, 19 in the $100,000 to $1,000,000 range, and the remainder were under $100,000. There were 290 people employed in the companies, up from 260 in 1985. The professional categories experienced no significant growth, but there was some growth in the technical category. The companies employed 60 scientists, 40 engineers, 50 programmers, 70 technicians, and 70 people in other categories.

Contracting Out at IOS

Between 1984 and 1986, the Institute managed 347 contracts with 111 different firms. Over 90 per cent of these contracts stayed in British Columbia and half the contracts produced tangible benefits. Non-financial support was also important, for it represented an estimated eight per cent of the direct value of the contracts.

Direct S&T Support

The total value of the contracts let over the three-year period was $13.7 million. The direct value of each year's contracts was over $4.5 million. Oceanography accounted for 50 per cent of this amount and hydrography for 44 per cent. Table IV-5 shows these data by scientific discipline.

Two contracts were let for over $1 million. One of them helped to transfer DOLPHIN technology, and the other

Table IV-5:
IOS Technology Transfer Contracts, 1984 to 1986, by Science Sector (Annual Average)

Science Sector	*Number of contracts*		*Value of contracts*	
	No.	*% of total*	*$000*	*% of total*
Oceanography	55	48	41	50
Biological Science	17	15	16	6
Hydrography	27	23	65	38
Other	16	14	16	6
Total	**115**	**100**	**40**	**100**

assisted with IOS technology transfer to Hermes Electronics of Halifax, Nova Scotia. IOS expertise in specific measurement systems and company expertise in fabrication and product quality control were combined to produce satellite-tracked drifting buoys. Since that time Hermes has delivered more than 475 drifting buoys, or 15 to 20 per cent of the world's supply of such buoys. (See the case of FGGE drifting buoys.)

Over 90 per cent of IOS contracts went to British Columbia firms. Nearly half the money spent on private sector S&T by IOS resulted in tangible benefits (see Table A-8, Appendix IV).

Non-Financial S&T Support

This support includes ship time and use of IOS facilities, such as office space and meeting rooms, as well as equipment for calibration, a water tunnel, and facilities for image processing, high pressure testing, and acoustic testing. No single private firm could afford these facilities. For example, Seakem Oceanography Limited did most of its initial work using the IOS laboratories, and in some cases continues to make use of IOS intensive test equipment, library services, and personnel.

Of the 347 IOS contracts from 1984 to 1986, one-third received non-financial support with a total value of $1 million. Half of this form of support went to contracts that achieved tangible benefits (see Table A-9, Appendix IV). Oceanographic contracts to B.C. firms received over 85 per cent of the estimated value of all non-financial support.

Non-financial support to universities includes research time on board ships, use of facilities, and supervision and training of graduate students. Between 15 and 20 graduate students and three or four post-doctoral fellows train at the Institute of Ocean Sciences and the Pacific Biological Station in Nanaimo each year. Several teaching exchanges occur. Every year about 30 university students receive training from summer jobs at the Institute.

A survey conducted in 1985 by Martin Schaeffer and Associates, a private consulting firm, showed that the private sector is satisfied with the Institute of Ocean Sciences' direct and indirect supporting role. Contract dollars are important. They make up about 10 per cent of the local sector's total revenue. However, Schaeffer found that most respondents think that softer forms of support are more important to technology transfer than contract dollars:

> *"The most useful role of IOS during the process of technology transfer is in so-called "soft" support. The commitment of time by IOS scientists and engineers, both with regard to specific technologies and more generally in the generation of ideas, is its most important form. Other useful forms of such support are use of library resources and access to other IOS equipment and facilities."*

Respondents consider the "form of assistance" IOS supplies to be appropriate, and in fact believe it to be an essential condition for commercializing many of their products. Form of assistance refers to: " . . . transfer of information and expertise plus a subsidy during the risky and expensive development phase, but not after products reach market. IOS transferred fourteen products to eight firms as of 1985. The projected sales value of these products was $65 million."

Biological Science

Total forecasted biological science expenditures were half of all DFO science 1986-87 expenditures. Hydrography and oceanography each accounted for one-quarter. Over 40 per cent of all DFO science contracts let in 1986-87 were for biological science. However, as shown in the preceding analyses, BIO and IOS biological science contracts were a small proportion of their respective totals. Since neither Institute represents the economic contribution made by DFO to sectors that depend on biological science, the following outlines some linkages and contributions biological science makes to other sectors in the Pacific and Scotia-Fundy regions.

Biological science outputs differ substantially from oceanography and hydrography outputs. It is unusual for biological science to produce pieces of hardware or other forms of products that can be marketed. More typically, the outputs are

information and advice that in most cases result in operational savings. DFO's biological science research is carried out primarily in support of fisheries management. The economics of this common property resource compels federal management for the benefit of all Canadians. Scientific research such as stock assessment, genetic and disease research, and fundamental research in aquaculture contribute directly to effective fisheries management. This in turn has a direct bearing on the health of an industry that accounts for 30 per cent of the value and over 60 per cent of the employment in oceans industries.

DFO Biological Science in the Scotia-Fundy Region

There are 20 PYs in biological oceanography, 40 PYs in the marine fish division, and 12 PYs in environmental ecology located within BIO. An additional 70 biological science PYs are located in Halifax. There are six hatcheries, four in Nova Scotia and two in New Brunswick, that employ 34 additional biological science PYs. Ninety more PYs are employed at the St. Andrews Biological Station, 67.5 of whom are in biological science.

Highlights of Scotia-Fundy Region biological science contributions to aquaculture and fishermen's incomes are provided below.

Aquaculture

The Department has a long history of salmonid hatchery operation and physiology, disease and nutrition studies associated with the mandate for protection and conservation of natural stocks, resulting in a considerable body of biological and technological expertise. Awareness of the developing salmonid culture industry in Europe, especially in Norway, the apparent potential for a similar development in Eastern Canada, and initiation and failure of a major multi-million dollar commercial development effort in salmonid farming (Sea Pool Enterprises) was followed up by a major development in marine farming by the Cape Breton Development Company (DEVCO).

This venture, which was designed to avoid the mistakes which led to an earlier failure, provides an opportunity to utilize DFO expertise in a variety of inputs: transfer of applicable technology, direct participation in the early exploratory developments, continuing technical advice and trouble-shooting, including disease diagnosis and treatment, and the development of relevant technical S&T programs. The Atlantic salmon farming industry, projected to be worth about $50 million in 1990, is the direct result of these biological science activities. For a more detailed description of these activities refer to case number four in the companion study.

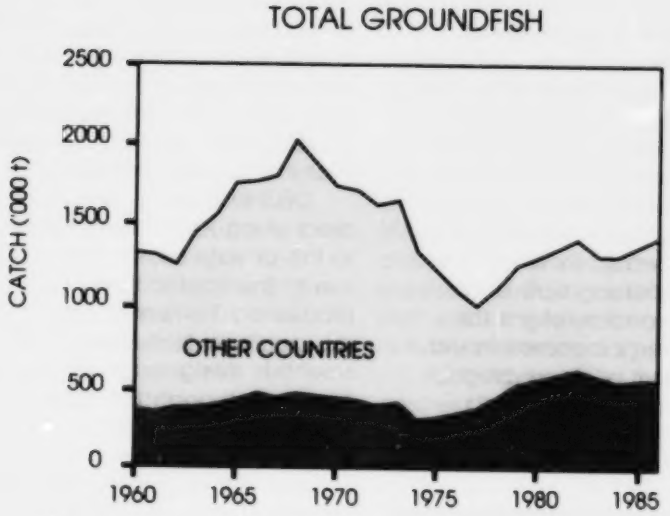
Fishermen's Incomes and the Science of Groundfish Stock Assessment

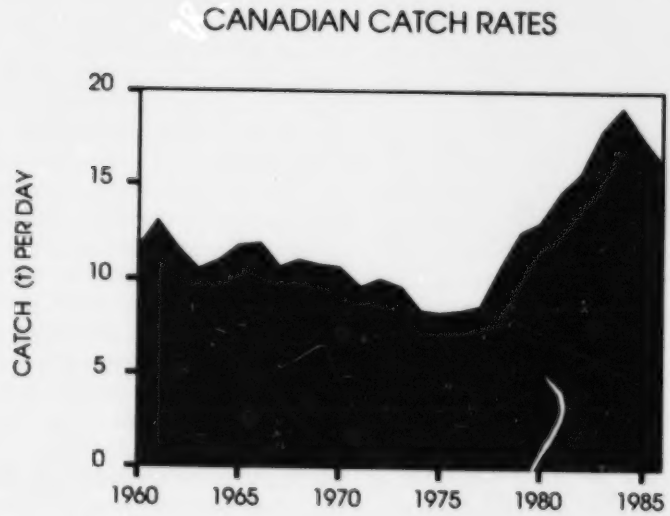
In 1974, it was apparent that Atlantic groundfish fisheries had collapsed and that a management system based on scientific advice was required to rehabilitate the stocks. The scientific systems that were applied grew out of those used by the International Commission for the Northwest Atlantic Fisheries (ICNAF). These were improved over the years by Canadian scientists to ensure adequate fish stocks. Atlantic Canada groundfish stocks now support a thriving industry, due to a management regime based on scientific advice.

Figure IV-1 shows that the positive impacts of this management system are: larger total biomass, which produces

FIGURE IV-1

GROUNDFISH CATCH AND CANADIAN OFFSHORE TRAWLER CATCH RATES IN TRADITIONAL ATLANTIC FISHING GROUNDS





higher catch rates; larger fish, which produce higher value products and lower processing costs; and more stable catches with less effort. The consistent application of this system increased total catch, profitability of harvesting and processing operations, average incomes of fishermen, and savings in harvesting costs.

It is difficult to specify precise dollar values for economic benefits resulting from DFO scientific research, the foundation of the management system. If groundfish stocks were allowed to dissipate as a result of consistent overfishing, catch rates for vessels operating within the fishery would decrease. This could increase harvesting costs per tonne of fish for a typical offshore groundfish trawler by as much as 20 per cent under a moderate overfishing scenario. This in turn would increase raw material costs of processing operations, resulting in poorer financial returns for processors. Trawlermen's incomes would also decline as a result of decreased landings. Under the same scenario a typical trawlerman's earnings could be reduced by as much as 25 per cent.

DFO Biological Science in the Pacific Region

Most of DFO's biological research on the west coast is carried out at the Pacific Biological Station in Nanaimo and the laboratory in West Vancouver. Genetics and biotechnology for aquaculture are two of the strongest areas, although they also do other types of biological research. A review of the scientific activities at these laboratories was not within the scope of this study.

Consultation with other government departments, the private sector and universities revealed that all parties support the need for strong government laboratories doing targetted basic research. Economic benefits received from DFO biological science activities included S&T contracts; direct contact in the form of free consultations and group discussions around specific problems; training support for graduate students who do their dissertations and theses within DFO laboratories and under DFO supervision; sponsorship of symposia; publication of results; and use of facilities. For example, the University of British Columbia is participating in improvements to the new building in the West Vancouver laboratory that will, at nominal cost, give the university access to many of the facilities at that location.

DFO biological research findings in the area of aquaculture are often transferred to the private sector. Led by Dr. E. Donaldson of the Pacific Region, DFO scientists pioneered the world's theoretical work in aquaculture. Norwegian and Japanese scientists designed their aquaculture industries based on that theoretical foundation. The Pacific aquaculture industry is a spinoff from DFO's Salmonid Enhancement Program (SEP). SEP provided 95 per cent of all eggs to the aquaculture industry between 1981 and 1986, is a significant source of skilled labour to this expanding industry, and provides continuous technical and biological science advice. In 1984 it had a value of only $700,000; by 1990 the British Columbia Salmon Farmer's Association expects production to reach $176 million.

Resource assessment and prediction, and oceanographic support are essential for effective fisheries management, and fisheries management enhances incomes and employment. A DFO Pacific Region study of potential benefits from optimal management of about 40 per cent of Pacific foodfish in 1978 showed that the optimal management programs would generate over $200 million compared to the base case scenario of about $120 million. The optimal program would generate over 1000 direct PYs, compared to the base case of 170 PYs, from this portion of the foodfish management program. Indirect impacts in boat building, vessel service industries, and consumption goods industries would generate considerably more employment.

Section V

Conclusions

This review of DFO's S&T involvement demonstrates clearly that DFO science activities result in many economic, technological, and industrial benefits to Canada. They directly affect an oceans sector with an annual output valued at over $8 billion, and employment of over 140,000 Canadians. And some benefits are not even measured in this study, for example, DFO contributions to international organizations and their private sector spinoffs.

With respect to overall government objectives, DFO's scientific activities enhance regional economic development; provide support for basic and applied research; train qualified people; transfer technology and develop it in other sectors; enhance cooperation among governments and the private sector; and maximize privatization of DFO research while maintaining sufficient in-house capability to ensure that research in the public interest is undertaken.

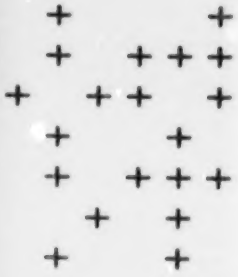
DFO S&T activities effect regional economic development. In contrast to total Canadian S&T expenditures, DFO's science expenditures are focused on regions outside Central Canada. Indeed, DFO spends a larger portion of its total science budget outside Central Canada than any other federal department. As many as 12,000 PYs of employment result from DFO science centre expenditures. Each DFO PY is associated with as many as five spinoff PYs in the private sector. And over 65 per cent are created in British Columbia and the Atlantic provinces.

Among federal S&T players and in certain areas, DFO is a leader, providing support to basic and applied S&T research in industry. For example, 80 per cent of DFO's extramural science payments go to industry. The comparable figure for all federal extramural S&T payments is 40 per cent. DFO is second only to EMR in the value of science contracts it manages each year, and leads in the number of contracts; over 1000 are managed each year.

Scores of professionals receive training each year at DFO research centres. University students work on summer projects. MA and PhD students complete theses and dissertations while gaining employment experience. Post-doctoral fellowships and staff exchanges with universities and industry are encouraged.

Judging from the analysis of two centres, the Institute of Ocean Sciences (IOS) and the Bedford Institute of Oceanography (BIO), DFO research laboratories are central in oceans technology transfer and development. They transfer and develop technology, manage science contracts, and provide non-financial support. Science contracts facilitate DFO's mission and at the same give private firms hundreds of chances to convert benefits from contracts into commercial opportunities. Non-financial support such as advice and access to facilities and testing equipment, also produces considerable benefits in other sectors.

IOS and BIO are the largest employers of ocean-related scientists and engineers in their respective regions. BIO managed more than 250 science contracts with over 100 firms between 1983 and 1985. These contracts were worth over $21 million. IOS managed over 340 contracts to more than 110 firms. They were worth $14 million. In both cases, more than 80 per cent of the contracts went to firms in each region.

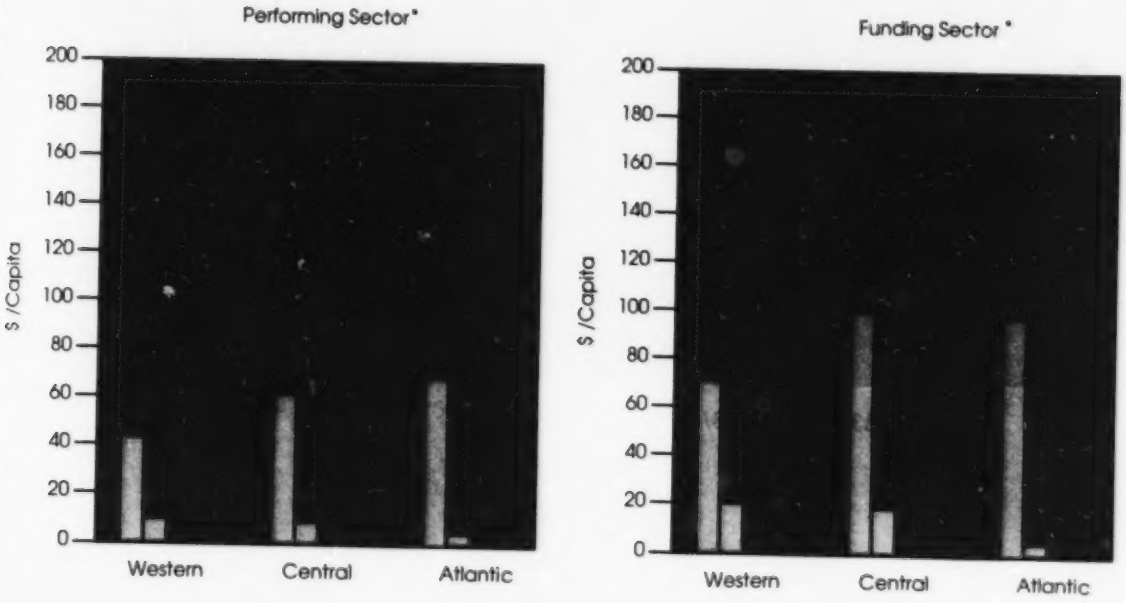


Appendix I

S&T Expenditures

FIGURE A-1

REGIONAL DISTRIBUTION OF S&T EXPENDITURE PER CAPITA BY SECTOR, 1985

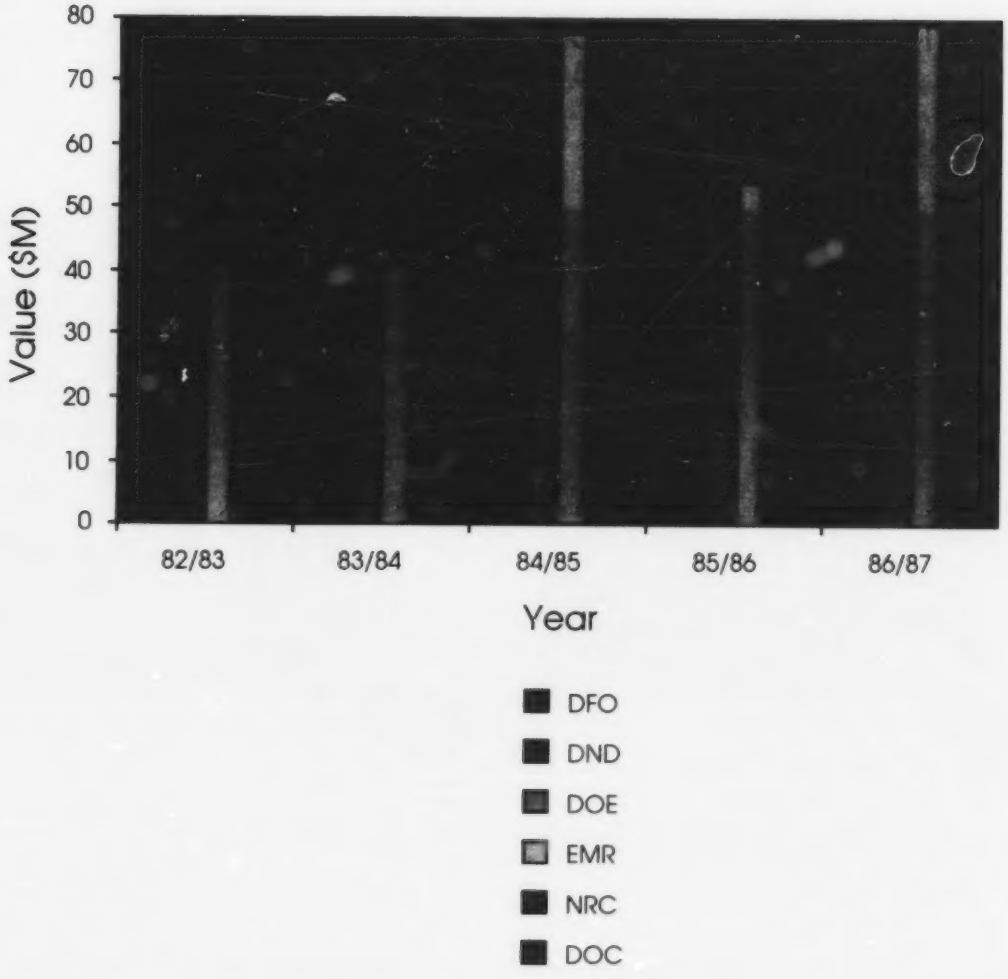


* erforming sectors conduct S&T; funding sectors provide financial support to others who conduct S&T.

Source: Statistics Canada. Cat. 88-201

FIGURE A-2

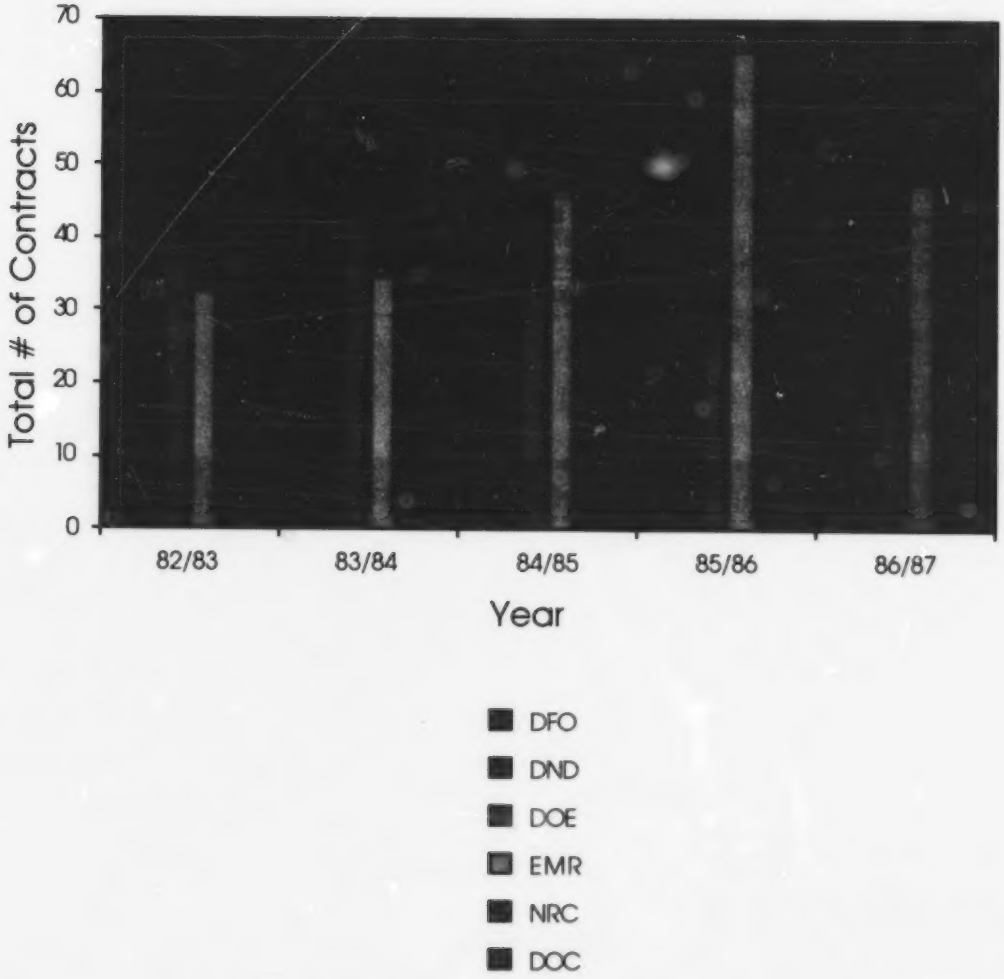
TOTAL VALUE OF SCIENTIFIC CONTRACTS PER YEAR, BY GOVERNMENT DEPARTMENT, 1982/83 TO 1986/87



Source: Supply and Services Canada. Research and Development Bulletin

FIGURE A-3

TOTAL NUMBER OF UNSOLICITED PROPOSAL CONTRACTS PER YEAR, BY GOVERNMENT DEPARTMENT, 1982/83 TO 1986/87



Source: Supply and Services Canada. Research and Development Bulletin

Table A-1:
Regional Distribution of S&T Expenditures, 1985*

By Performing Sector

Sector	Western Provinces	Central Canada	Atlantic Provinces	Canada
		($000,000)		
Federal Government	$ 325	$ 893	$157	$1,375
Provincial Government	$ 77	$ 126	$ 9	$ 212
Business Enterprises	$ 526	$2,754	$ 50	$3,330
Higher Education & Private Non-Profit	$ 465	$1,042	$106	$1,613
All Sectors	**$1,393**	**$4,815**	**$322**	**$6,530**
		% Distribution by Sector		
Federal Government	23.6	65.0	11.4	100
Provincial Government	36.3	59.4	4.3	100
Business Enterprises	15.8	82.7	1.5	100
Higher Education & Private Non-Profit	28.8	64.6	6.6	100
All Sectors	**21.3**	**73.7**	**5.0**	**100**
		% Distribution by Region		
Federal Government	23.3	18.6	48.8	21.1
Provincial Government	5.5	2.6	2.8	3.2
Business Enterprises	37.8	57.2	15.5	51.0
Higher Education & Private Non-Profit	33.4	21.6	32.9	24.7
All Sectors	**100.0**	**100.0**	**100.0**	**100.0**

* Source: Statistics Canada. Cat. 88-201.

Table A-2:
Regional Distribution of S&T Expenditure Per Capita, by Performing Sector, 1985*

Performing Sector	**Region**			
	Western Provinces	Central Canada	Atlantic Provinces	Canada
		$ per capita		
Federal Government	44.13	57.66	68.53	54.89
Provincial Government	10.59	8.14	3.93	8.46
Business	71.21	177.83	21.82	132.46
Other	63.92	67.28	46.27	64.39
Average	**189.85**	**310.91**	**140.55**	**260.66**

Regional Distribution of S&T Expenditure per Capita, by Funding Sector, 1985*

Funding Sector	**Region**			
	Western Provinces	Central Canada	Atlantic Provinces	Canada
		$ per capita		
Federal Government	70.94	100.79	90.35	91.37
Provincial Government	21.03	17.43	3.49	17.2
Business	56.23	145.99	19.64	108.61
Other	41.65	46.68	27.06	43.47
Average	**189.85**	**310.91**	**140.55**	**260.66**

* Source: Statistics Canada. Cat. 88-201

By Funding Sector

Western Provinces	Central Canada	Atlantic Provinces	Canada
	($000,000)		
$ 521	$1,561	$207	$2,289
$ 153	$ 270	$ 8	$ 431
$ 415	$2,261	$ 45	$2,721
$ 304	$ 723	$ 62	$1,089
$1,393	**$4,815**	**$322**	**$6,530**
	% Distribution by Sector		
22.8	68.2	9.0	100
35.5	62.6	1.9	100
15.3	83.1	1.6	100
27.9	66.4	5.7	100
21.3	**73.7**	**5.0**	**100**
	% Distribution by Region		
37.4	32.4	64.3	35.0
11.0	5.6	2.5	6.6
29.8	47.0	14.0	41.7
21.8	15.0	19.2	16.7
100.0	**100.0**	**100.0**	**100.0**

Appendix II

DFO Science Facilities by Community

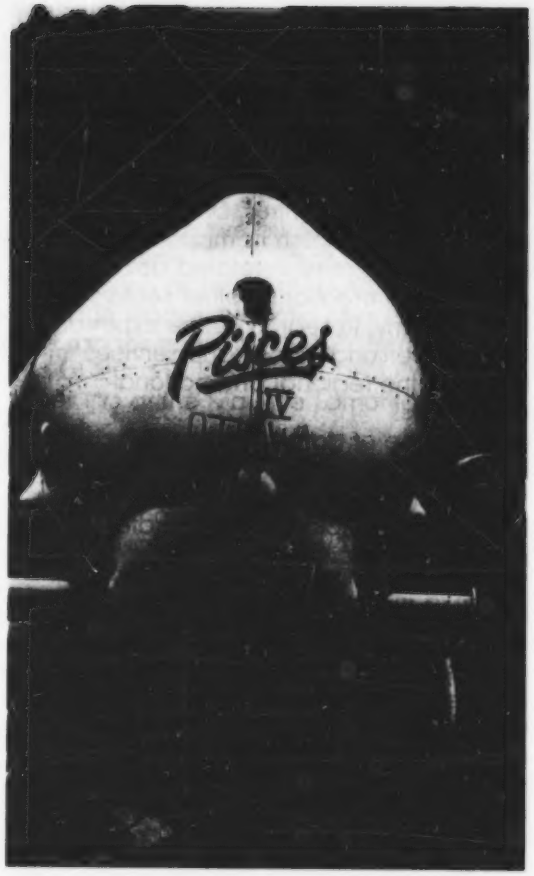
Table A-3:
DFO Science Facilities by Community, 1987/88

Location		Total PYs	Population	% Population Over 15 Years	Participation Rate
Bishop's Falls, Nfld.		4.2	4,213	3,097	51.8
Marystown, Nfld.		2.0	6,660	4,895	54.3
Springdale, Nfld.		1.3	3,555	2,613	51.8
*St. John's, Nfld.		237.9	96,216	70,719	60.3
Other Nfld.		1.0			
Cardigan, P.E.I.		3.0	346	264	68.5
Miminegash, P.E.I.		3.0	288	220	68.5
Other P.E.I.		0.7			
Cobequid, N.S.		4.1			
Coldbrook, N.S.		3.0	617	482	61.0
*Dartmouth, N.S.		446.9	65,243	50,955	71.3
*Halifax, N.S.	(2)	135.1	113,577	88,704	71.3
Margaree, N.S.		3.0	282	220	60.6
Mersey Point, N.S.		4.6	458	358	55.5
Yarmouth, N.S.		3.0	7,475	5,838	55.5
Other N.S.		1.5			
Charlo, N.B.		3.0	1,602	1,251	57.2
Mactaquac Heights, N.B.		11.5	83	65	62.7
Millbank, N.B.		2.0	198	152	57.2
Miramichi, N.B.		3.5	66	51	57.2
Moncton, N.B.	(3)	75.7	55,468	42,544	65.5
Saint John, N.B.		4.2	80,521	61,760	62.7
*St. Andrews, N.B.		73.5	1,612	1,236	66.2
Other N.B.		2.8			
*Mont-Joli, Que.		157.0	6,700	5,313	59.6
*Ste-Anne-de-Bellevue, Que.		20.0	4,140	3,283	69.3
*Burlington, Ont.	(2)	152.9	116,675	92,523	69.5
Kenora, Ont.		1.0	9,621	7,629	69.5
*Ottawa, Ont.	(2)	162.0	300,763	238,505	70.7
Owen Sound, Ont.		3.0	19,804	15,705	65.6
Sault Ste. Marie, Ont.		4.0	80,905	64,158	63.8
Toronto, Ont. (Metro)		2.0	3,345,121	2,652,681	72.7
Dauphin, Man.		1.0	8,971	6,961	65.2
Gunton, Man.		4.0	120	93	68.4
*Winnipeg, Man.		126.0	594,551	461,372	68.4
Bowser, B.C.		3.0	119	94	60.4
Cultus Lake, B.C.		11.0	481	382	67.9
*Nanaimo, B.C.		176.5	49,029	38,929	60.4
Prince Rupert, B.C.		3.0	15,755	12,509	74.9
*Sidney, B.C.		262.5	8,982	7,132	60.4
Vancouver, B.C.	(2)	4.5	431,147	342,331	67.9
West Vancouver, B.C.		25.0	36,266	28,795	67.9
Total		**2,148.9**	**5,467,630**	**4,313,818**	

Legend:

* Communities included in greater detail.
** Population from 1981 Census data.
(2) There are two DFO facilities in the community.
(3) There are three DFO facilities in the community.

Estimated Labour Force	DFP PYs as % of Est. Labour Force	Provincial Mult. Jobs
1,604	0.26	
2,658	0.08	
1,353	0.10	
42,643	0.56	421.4
181	1.66	
151	1.99	
294	1.02	
36,331	1.23	1,345.5
63,246	0.21	327.3
133	2.25	
199	2.32	
3,240	0.09	
716	0.42	
41	28.29	
87	2.30	
29	12.09	
27,866	0.27	
38,723	0.01	
818	9.98	186.2
3,167	4.96	920.3
2,275	0.88	116.5
64,304	0.24	640.1
5,302	0.02	
168,623	0.10	611.6
10,302	0.03	
40,933	0.01	
1,928,499	0.00	
4,539	0.02	
64	6.28	
315,578	0.04	375.8
57	5.26	
259	4.24	
23,513	0.75	756.2
9,370	0.03	
4,308	6.09	928.8
232,443	0.00	
19,552	0.13	
3,083,400		**6,621.0**



Appendix III

Employment Impact of DFO Science

Introduction

The purpose of this employment impact analysis is to estimate the magnitude of spinoff employment generated by expenditures on wages and S&T contract dollars at DFO research centres. DFO's primary goal is to accomplish its mission, but a by-product of this mission-related activity is employment creation in other sectors of the economy. Research centre expenditures on personal goods and services stimulate the regional and national economies.

Because of data limitations (discussed in more detail below), it was not possible to compare the employment generated by DFO with employment generated by other types of science-based organizations.

A personal income multiplier was used to estimate the multiplier effects of research centre expenditures on wages and S&T contracts. It was assumed that 100 per cent of the S&T contract dollars were wages. These were added to the estimated expenditures by each centre on wages (see below), and the personal income multiplier was applied to this sum. Employment estimates were obtained by dividing the multiplied income by the average income at each location.

Method

Data

Information on 15 DFO science centres was available from Statistics Canada. It included the location of each centre, their 1985/86 total expenditures and 1985/86 person-year complements, and selected data pertaining to extramural payments to performers of scientific activity. Complete contract data were not available for all centres (see Table A-4).

DFO Science Communities

In situations where communities had more than one DFO science centre, combined totals were provided for the community. A total budget of $168.6 million and 2342 person-years in 1985/86 was accounted for by 11 communities with 15 DFO science centres. These communities had a total population of 1,357,488 and an estimated labour force of 746,618. The labour force was estimated by:

a) applying provincial ratios of "population over 15 years of age"[1] to the population figure;
b) applying economic region participation rates[2] to the population over 15 years of age.

For major cities, average income data were obtained for the most recent year (1984) from income tax returns.[3] For smaller communities average income was estimated from average incomes in the closest city.

Domestic and Provincial Personal Income Multipliers

Economic impact studies use current expenditure data together with an input-output (I/O) model. Using the Statistics Canada I/O model would cost $500 for one run to determine a single national multiplier. In order to run the model, expenditures for each DFO facility, by

1. Statistics Canada. *Postcensal Annual Estimates of Population by Marital Status, Age, Sex and Components of Growth for Canada, Provinces and Territories.* June 1, 1985. Volume 3, Third Issue. Supply and Services Canada. January 1986. Cat. 91-210, Table 2, page 41.

2. Statistics Canada. *The Labour Force.* Supply and Services Canada. August 1987. Cat. 71-001, Table 54, pg. 81-82.

3. Revenue Canada Taxation. *Taxation Statistics.* 1986 Edition. Supply and Services Canada. 1986. Summary Table 1.

602 commodity categories, would be required. A complete economic impact analysis was beyond the scope of this study.

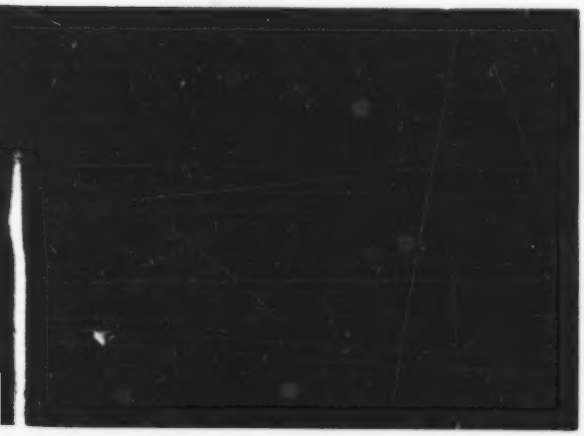
To determine the spinoff jobs from federal expenditures at the DFO science centres, domestic and provincial personal income multipliers were obtained.[4] Given interprovincial trade the provincial multipliers are less than the national figures. That is, not all induced personal income will be retained in the province in which an industry expansion occurs; some will "leak" out to other provinces.

Total induced domestic and provincial personal income can be estimated by using their respective multipliers. The domestic and provincial multipliers for oceans industries were not available. Average multipliers for selected industries resembling the oceans industries were used as proxies for the missing multipliers.

Estimates of Employment

To determine spinoff employment, the multipliers were applied to DFO science research centre budgets as follows:

a) 65 per cent[5] of the budget plus the total value of the S&T extramural contracts was multiplied by the multiplier minus one to determine the additional induced personal income; and



b) that value was divided by the average income for all 11 communities within which DFO research centres are located for the domestic multiplier, and by average incomes at the respective communities for the provincial multiplier.

Results

Given the assumptions noted above, the DFO science budget of $168.6 million produced approximately $218.2 million in additional personal income, and 11,781 other jobs across Canada in 1985/85. On average this means that one DFO PY is associated with five other PYs in the Canadian economy. Because of differences in factors such as regional multipliers and average wages, the ratio of associated PY's ranges from one DFO PY to four other PYs at BIO and IOS, to one DFO PY to eight other PYs at the Maurice Lamontagne Institute.

Of course, if the average wages in the community had been higher or if the multipliers had been lower, the overall employment generated by DFO expenditures on wages and S&T extramural contracts would also be reduced. For example, if multipliers were reduced by 25 per cent, each DFO PY would be associated with three other PYs (see Table A-5). The use of a community average wage may have overestimated the number of spinoff jobs. High-wage earners, such as DFO scientific personnel, spend much of their wages on high technology products, and the average wages in high technology industries are higher than the average wages in small communities.

To ensure conservative employment estimates, the capital portion of each research centre expenditure (about one-third of their total budgets) was excluded from the analysis. About $12 million of this was spent on equipment in 1986-87. Some of the equipment was imported. However, fully $23 million was spent on Canadian-built ships and local construction.

4. Zuker, R.C. Department of Regional Economic Expansion. *An interprovincial Input-Output Model: Version III*. Economic Development Analysis Division. May 1976.

5. On average, expenditures on wages and salaries account for 65 per cent of industry expenditures in the U.S.A. U.S. Department of Commerce. *Statistical Abstract of the United States*. 103rd Edition. 1982-83. Table 703, pg. 425.

Table A-4:
DFO Research Facilities: Employees, Budgets, S&T Contracts to Other Sectors, and Multiplier Impacts, 1985/86.

	Pacific Biological Station Nanaimo, B.C.	Institute of Ocean Sciences Sidney, B.C.	Fisheries Research Branch Winnipeg, Man.	Great Lakes Research Branch & Bayfield Lab for Marine Science & Surveys Burlington, Ont.	Fisheries Research Directorate, Marine Environmental Data Services Br. & Canadian Hydrographic Service Ottawa, Ont.
Population (1986)	49,029	8,982	594,551	116,675	300,763
Estimated Labour Force	23,513	4,308	315,578	64,304	168,623
Average Income (1984)	$17,292	$19,391	$16,948	$22,531	$22,316
Budget	$17,000,000	$25,056,000	$9,158,000	$12,971,400	$10,825,000
No. of Employees	215.0	349.6	136.6	200.8	176.5
% of Total Employees	9.18	14.92	5.83	8.57	7.54
% of Estimated Labour Force	0.91	8.12	0.04	0.31	0.10
Contracts to:					
University	$240,841	$35,500	$176,600	$222,767	$505,300
%	15.81	3.44	49.92	42.33	35.07
Private Sector	$1,275,414	$996,400	$177,200	$261,782	$840,200
%	83.70	96.56	50.08	49.74	58.31
Other	$7,452			$41, 750	$95,300
%	0.49			7.93	6.61
(incl. Non-profit org., Federal, Prov.& Municipal Govt. & Other)					
Total Contracts	**$1,523,707**	**$1,031,900**	**$353,800**	**$526,299**	**$1,440,800**
Contracts as % Budget	**8.96**	**4.12**	**3.86**	**4.06**	**13.31**
Domestic Multiplier a)	2.74	2.74	2.98	2.94	2.94
Provincial Multiplier b)	2.04	2.04	2.01	2.61	2.61
Number of Spinoff Jobs a)	1,181.5	1,627.3	674.3	938.4	888.1
b)	756.2	928.8	375.8	640.1	611.6
Provincial Jobs	971.2	1,278.4	512.4	840.9	788.1
% of Estimated Labour Force	4.13	29.68	0.16	1.31	0.47
Personal Income a)	$21,878,250.2	$30,133,842.0	$12,486,870.0	$17,377,955.5	$16,445,477.0
b)	$13,076,655.3	$18,011,032.0	$6,369,565.0	$14,421,911.5	$13,648,050.5

Table A-5:
Multiplier Impacts: Magnitude of Multiplier Reduced by 25%*

	Pacific Biological Station Nanaimo, B.C.	Institute of Ocean Sciences Sidney, B.C.	Fisheries Research Branch Winnipeg, Man.	Great Lakes Research Branch & Bayfield Lab for Marine Science & Surveys Burlington, Ont.	Fisheries Research Directorate, Marine Environmental Data Services Br. & Canadian Hydrographic Service Ottawa, Ont.
Population (1986)	49,029	8,982	594,551	116,675	300,763
Estimated Labour Force	23,513	4,308	315,578	64,304	168,623
Average Income (1984)	$17,292	$19,391	$16,948	$22,531	$22,316
Budget	$17,000,000	$25,056,000	$9,158,000	$12,971,400	$10,825,000
No. of Employees	215.0	349.6	136.6	200.8	176.5
% of Total Employees	9.18	14.92	5.83	8.57	7.54
% of Estimated Labour Force	0.91	8.12	0.04	0.31	0.10
* Source: Statistics Canada Data					
Domestic Multiplier	2.06	2.06	2.24	2.21	2.21
Provincial Multiplier	1.53	1.53	1.51	1.96	1.96
Number of Spinoff Jobs	716.3	986.7	420.6	582.9	551.6
	385.4	473.3	188.8	380.7	363.7
Provincial Jobs	600.4	822.4	325.4	581.5	540.2
% of Estimated Labour Force	2.55	19.10	0.10	0.90	0.32

Arctic Biological Station Ste Anne-de-Bellevue, Que.	Fisheries Research Br. — Que. Region & Champlain Centre for Marine Science & Surveys, Mont-Joli (Moved to Maurice Lamontagne Institute)	Bedford Institute Dartmouth N.S.	Fisheries Research Branch Scotia-Fundy Halifax, N.S.	St. Andrews BIO Station St. Andrews, N.B.	Fisheries Research St. John's Nfld.	Total
4,140	6,700	65,243	113,577	1,612	96,216	1,357,488
2,275	3,167	36,331	63,246	818	42,643	746,618
$16,824	$17,069	$18,594	$19,633	$15,799	$17,614	$18,518
$2,355,600	$12,850,800	$42,911,000	$12,377,000	$5,748,000	$17,333,000	$168,585,800
27.9	152.8	664.0	146.0	97.0	176.2	2,342
1.19	6.52	28.35	6.23	4.14	7.52	100
1.23	4.82	1.83	0.23	11.86	0.41	0.31
N/A	$386,069	$263,000	N/A		$302,507	$2,132,584
	9.85	7.78			8.5	13.48
	$2,587,229	$2,930,000		$84,900	$3,242,812	$12,395,937
	66.02	86.66		100.00	91.12	78.35
	$945,839	$188,000			$13,581	$1,291,922
	24.13	5.56		0.38	0.38	8.17
0.00	**$3,919,137** **30.50**	**$3,381,000** **7.88**	**0.00**	**$84,900** **1.48**	**$3,558,900** **30.53**	**$15,820,443** **9.38**
2.89	2.89	2.73	2.73	2.69	2.30	
2.28	2.28	1.80	1.80	1.77	1.49	
156.3	1,252.5	2,921.6	751.6	348.7	1,040.8	11,781
116.5	920.3	1,345.5	327.3	186.2	412.4	6,621
144.4	1,073.1	2,009.5	473.3	283.2	588.6	8,963
6.35	33.88	5.53	0.75	34.62	1.38	1.20
$2,893,854.6	$23,194,376.7	$54,102,549.5	$13,917,936.5	$6,457,659.0	$19,272,955.0	$218,161,726.0
$1,959,859.2	$15,708,361.0	$25,018,520.0	$6,436,040.0	$2,942,247.0	$7,264,421.5	$124,856,663.0

Arctic Biological Station Ste-Anne-de-Bellevue, Que.	Fisheries Research Br. — Que. Region & Champlain Centre for Marine Science & Surveys, Mont-Joli (Moved to Maurice Lamontagne Institute)	Bedford Institute Dartmouth N.S.	Fisheries Research Branch Scotia-Fundy Halifax, N.S.	St. Andrews BIO Station St. Andrews, N.B.	Fisheries Research St. John's Nfld.	Total
4,140	6,700	65,243	113,577	1,612	96,216	1,357,488
2,275	3,167	36,331	63,246	818	42,643	746,618
$16,824	$17,069	$18,594	$19,633	$15,799	$17,614	$18,518
$2,355,600	$12,850,800	$42,911,000	$12,377,000	$5,748,000	$17,333,000	$168,585,800
27.9	152.8	664.0	146.0	97.0	176.2	2,342
1.19	6.52	28.35	6.23	4.14	7.52	100
1.23	4.82	1.83	0.23	11.86	0.41	0.31
2.17	2.17	2.05	2.05	2.02	1.72	
1.71	1.71	1.35	1.35	1.33	1.12	
96.5	773.7	1,769.0	455.1	210.0	580.4	7,143
64.6	510.5	588.7	143.2	79.2	98.9	3,277
92.5	663.3	1,252.7	289.2	176.2	275.1	5,619
4.07	20.94	3.45	0.46	21.54	0.65	0.75

Appendix IV

BIO and IOS Contract and Non-Financial Support Data

The data supplied for this study from BIO and IOS consisted of financial and benefit type data for each technology contract let by the respective Institute over a three-year period (BIO-1983 to 1985; IOS-1984 to 1986). The benefit type originally consisted of nine categories:

1- Manufacture new hardware item
2- Improvements to existing hardware item manufactured by company
3- Development of new software item with commercial potential
4- Improvements to existing software item marketed by company
5- Offer new service
6- Improvements to existing service offered by company
7- Gains additional experience/expertise in current field of interest
8- Gains experience/expertise in new field
9- Other

For the purposes of this study, these categories were grouped into two broad categories: tangible (1-6), and intangible (7-9). In the case where a contract provided a mix of benefits to the company, the lowest-value benefit code was used for analytical purposes.

Tables of direct and non-financial support data for BIO and for IOS follow. Data expressed in the report are the average values over the three-year period.

Table A-6:
Direct value of BIO technical transfer contracts, 1983 to 1985, by science sector, by region, and by type of benefit (Annual Average)

Science Sector	Average No.	%	Average $	%
Oceanography	29.3	(35.0)	134,000	(54.6)
Biological science	34.0	(40.7)	19,000	(9.1)
Hydrography	20.3	(24.3)	129,000	(36.3)
Total	**83.6**	**(100.0)**		**(100.0)**

Region	Average No.	%	Average $	%
Western	7.3	(8.7)	380,000	(38.4)
Central	3.3	(4.0)	126,000	(5.8)
Atlantic	72.0	(86.1)	55,000	(55.0)
Foreign	1.0	(1.2)	61,000	(0.8)
Total	**83.6**	**(100.0)**		**(100.0)**

Benefit Type	Average No.	%	Average $	%
Tangible	29.6	(35.4)	80,000	(33.0)
Intangible	54.0	(64.6)	75,000	(67.0)
Total	**83.6**	**(100.0)**		**(100.0)**

Table A-7:
Non-financial support value of BIO technical transfer contracts, 1983 to 1985, by science sector, by region, and by type of benefit (Annual Average)

Science Sector	Average No.	%	Average $	%
Oceanography	13.0	(27.1)	54,000	(52.3)
Biological science	24.0	(50.0)	17,000	(29.8)
Hydrography	11.0	(22.9)	22,000	(17.9)
Total	**48.0**	**(100.0)**		**(100.0)**

Region	Average No.	%	Average $	%
Western	3.7	(7.7)	46,000	(12.5)
Central	3.0	(6.3)	36,000	(7.9)
Atlantic	41.0	(85.4)	26,000	(77.4)
Foreign	0.3	(0.6)	10,000	(2.2)
Total	**48.0**	**(100.0)**		**(100.0)**

Region	Average No.	%	Average $	%
Tangible	14.3	(29.8)	37,000	(39.1)
Intangible	33.7	(70.2)	24,000	(60.9)
Total	**48.0**	**(100.0)**		**(100.0)**

Table A-8:
Direct value of IOS technical transfer contracts. 1984 to 1986, by science sector, by region, and by type of benefit (Annual Average)

Science Sector	Average No.	%	Average $	%
Oceangraphy	55.3	(47.8)	41,000	(49.9)
Biological science	17.3	(15.0)	16,000	(5.9)
Hydrography	27.3	(23.6)	64,000	(38.6)
Other	15.7	(13.6)	16,000	(5.6)
Total	**115.6**	**(100.0)**		**(100.0)**

Region	Average No.	%	Average $	%
Western	109.3	(94.6)	38,000	(90.9)
Central	3.3	(2.8)	86,000	(6.2)
Atlantic	1.0	(0.9)	123,000	(2.7)
Foreign	2.0	(1.7)	4,000	(0.2)
Total	**115.6**	**(100.0)**		**(100.0)**

Benefit Type	Average No.	%	Average $	%
Tangible	31.6	(27.3)	67,000	(46.4)
Intangible	84.0	(72.7)	29,000	(53.6)
Total	**115.6**	**(100.0)**		**(100.0)**

Table A-9:
Non-financial support value of IOS technical transfer contracts, 1984 to 1986, by science sector, by region, and by type of benefit (Annual Average)

Science Sector	Average No.	%	Average $	%
Oceanography	24.7	(70.0)	14,000	(88.3)
Biological science	—	—	—	—
Hydrography	6.0	(17.0)	4,000	(6.0)
Other	4.6	(13.0)	5,000	(5.7)
Total	**35.3**	**(100.0)**		**(100.0)**

Region	Average No.	%	Average $	%
Western	34.3	(97.2)	11,000	(97.2)
Central	0.3	(0.8)	10,000	(2.6)
Atlantic	—	—	—	—
Foreign	0.7	(2.0)	1,000	(0.2)
Total	**35.3**	**(100.0)**		**(100.0)**

Benefit Type	Average No.	%	Average $	%
Tangible	9.3	(26.4)	19,000	(46.3)
Intangible	26.0	(73.6)	8,000	(53.7)
Total	**35.3**	**(100.0)**		**(100.0)**